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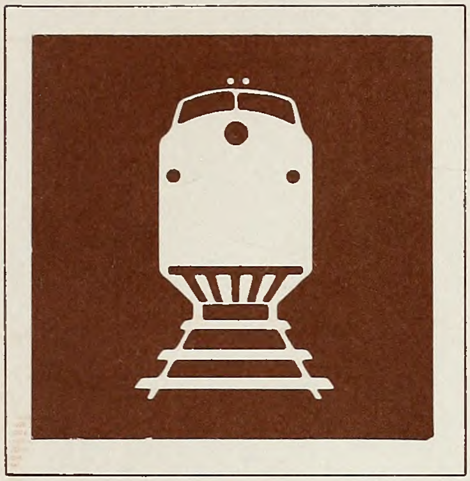

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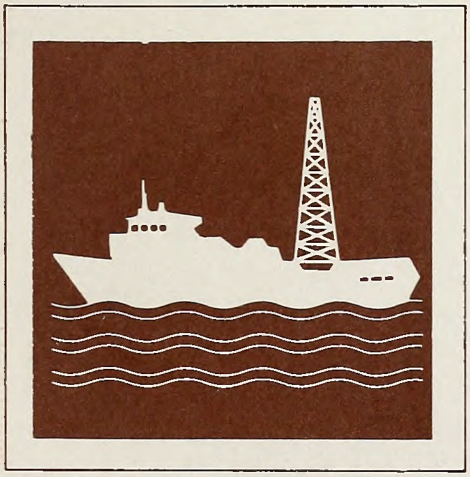

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ENVIRONMENTAL GEOLOGIC ATLAS
OF THE
NORTH CAROLINA COASTAL ZONE:
DARE, HYDE, TYRRELL, AND WASHINGTON COUNTIES

by

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Greenville, North Carolina

November, 1983

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ABSTRACT

The Albemarle-Pamlico peninsula of North Carolina includes Dare, Hyde, Tyrrell, and Washington counties. The peninsula is a low-lying, tidewater region bordered on the north by the Albemarle Sound and on the east and south by the Pamlico Sound and Pamlico River. In addition, Dare and Hyde counties include a portion of the barrier island system that is about 120 miles in length (Figure 1).

The area is characterized by poorly integrated coastal streams, organic soils, extensive swamp forests, marshes, and evergreen wetlands, and a low astronomical tidal range. Average annual rainfall is about 51 inches. Topography is very low with elevations on the peninsula usually less than 20 feet. Population densities are low; only 0.65 percent of North Carolina's population live in the four-county area (1980 Census, Adv. Rept).

The Environmental Geologic Atlas of the North Carolina Coastal Zone: Dare, Hyde, Tyrrell, and Washington counties, consists of a text that is a summary of published and unpublished data on this portion of the North Carolina coastal region and more than 250 large-scale (1:24,000) overlay maps (and keys) that are separate from the text. Sixty-two U. S. Geological Survey 7 1/2 minute topographic quadrangles were used as base maps for the mapping project. One smaller scale map (Mineral and Energy Resources) (1:126,720) was also compiled; a composite of N. C. Department of Transportation highway maps for the four counties was used as the base map. The Mineral and Energy Resources map shows the locations and thicknesses of the peninsular peat deposits.

The large scale maps (1:24,000) were prepared as four series:

1) Physical Properties

   Information on soil properties and man-made lands (Soil Conservation Service data). Soils were grouped into nine mapping units based on textural and drainage characteristics.

2) Land Use and Land Cover

   Information on land use and land cover mapped from 1980-1981 aerial transparencies and other available data sources: residential and other built-up areas; crop and pasturelands; other farmlands; forestlands; wetlands, including evergreen wetlands (pocosins), swamp forests, and marshes; and barren lands, including mining areas, beaches, dunes, and areas in transition from one land use to another. Mapping units are based on the USGS Land Use and Land Cover Classification System of Anderson et al. (1976).

3) Drainage and Bathymetry

   Information on changes in artificial drainage system (canals and ditches) since the USGS 7 1/2 minute topographic maps were revised (1970-1974) and bathymetry of the sounds.

4) Active Processes

Information on the relict and modern geomorphic features of the Outer Banks and the processes that shaped them within four environmental systems: Beach and Foredune, Barrier Ridge and Flat, Brackish and Salt Marshes, and Nearshore. An inventory of shoreline changes due to erosion is included for both mainland and barrier islands.

These maps were compiled on heavy, transparent plastic drafting film (Herculene) and are designed to be used as overlays to the USGS 7 1/2 minute topographic maps. All maps prepared for this atlas project are on file with the N. C. Department of Natural Resources and Community Development and with the Institute for Coastal and Marine Resources, East Carolina University. Maps and explanatory keys for map use are available for purchase by the general public for a nominal copying fee. One topographic base map (I-3, Engelhard East) and the four map series overlays that accompany it have been reduced to page size and included in Appendix A for exemplary purposes (Plates I-IV, page A-1-A-4). Keys to the four map series are also included in Appendix A (pages A-5-A-10). Data for exploratory oil wells are found in Appendix B.

The atlas is an inventory of environmental data for the region and is organized to serve as both a planning and management tool for local and State agencies and as a baseline of environmental conditions against which ongoing change can be measured and evaluated in the future.

INTRODUCTION

This atlas contains environmental geologic data on four North Carolina counties: Dare, Hyde, Tyrrell, and Washington (Figure 1). These four counties occupy 80 percent of the 1,634 square mile Albemarle-Pamlico peninsula which is located in the central section of the North Carolina Coastal Plain. In addition, Dare County includes a 100-mile long barrier island system that extends along the coast from a point several miles north of Duck, North Carolina, to Hatteras Inlet. Hyde County also includes Ocracoke, a barrier island approximately 18 miles long.

The peninsula is a low-lying, tidewater region bordered by two sounds, Albemarle and Pamlico, and an estuarine river, the Pamlico. The area is characterized by poorly integrated coastal streams, deep organic soils, extensive swamps, marshes, and evergreen wetlands, and a low astronomical tidal range. Average annual rainfall is about 51 inches (Heath 1975). The summers are hot and humid, but winters are mild.

Inherent limitations of peninsular lands for certain types of development are reflected in low population densities (Coastal Zone Resources Corp. 1976). According to the 1980 Census of Population and Housing (Advance Report), only 0.65 percent of North Carolina's population live in the four-county area. Since 1970, the populations of Washington, Tyrrell, and Hyde Counties have each increased only slightly, but the population of Dare County has increased over 90 percent due to development on the Outer Banks (Table 1).

Settlement of the peninsula began during the colonial period. From the time of the earliest colonial settlements until the early 1960's, land privately owned was generally held in small tracts. During the 1960's, this pattern began to change. By 1975, 40 percent of the peninsula was owned by corporate farms (Heath 1975), including large tracts of commercial woodlands and the most extensive peat deposits in the State. However, some tracts have recently been sold to smaller interests, and some areas will probably be purchased by the State for natural areas. Although clearing and ditching operations have been used on the peninsula for almost 200 years (Heath 1975), such operations have recently been accelerated. The character of the region has been greatly altered over the past decade by extensive clearing and by the construction of complex systems of drainage canals. Large-scale corporate farming and the potential for extensive peat mining on corporate farm lands suggest that extensive changes in land use, land cover, and drainage will occur on the peninsula in the future.

The Environmental Geologic Atlas Project: Role and Use

Preparation of this atlas was initiated in 1979 when the need for more detailed information on environmental processes, physical properties, changes in land and water use, and other factors was recognized by State government. The four-county area that comprises the Albemarle-Pamlico peninsula and its Outer Banks is part of a complex and dynamic natural system that has been greatly

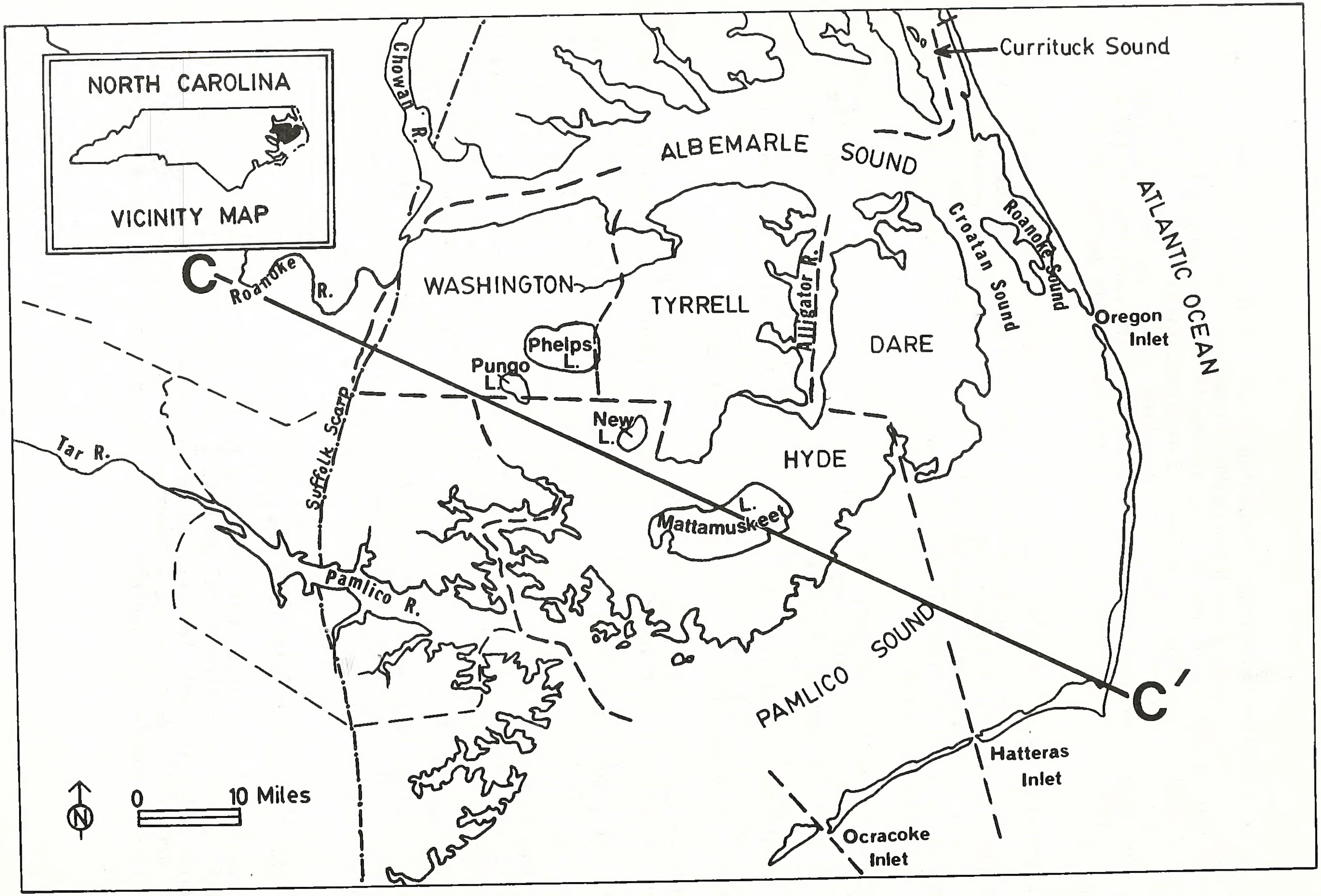


Figure 1. Index Map of the North Carolina Coastal Zone: Dare, Hyde, Tyrrell, and Washington Counties. (C-C' indicates line of geologic cross section, see Figure 15)

Table 1. 1980 Census of Population and Housing: North Carolina Coastal Zone (Dare, Hyde, Tyrrell, and Washington Counties). Advance Report.

PERSONS BY RACE AND SPANISH ORIGIN AND HOUSING UNIT COUNTS

NORTH CAROLINA Counties County Subdivisions	Persons									Housing units		
				Race								
	1980	1970	Percent change 1970 to 1980	White	Black	Am. Indian. Eskimo, and Aleut	Asian and Pacific Islander	Other	Spanish origin	1980	1970	Percent change, 1970 to 1980
Dare County	13,377	6,995	91.2	12,468	827	18	40	24	56	11,006	5,057	117.6
Atlantic township	3,737	1,141	227.5	3,699	20	3	10	5	21	4,851	1,883	157.6
Kill Devil Hills town	1,796	357	403.1	1,771	10	1	10	4	12	2,820	1,069	163.8
Southern Shores town	395	...	...	395	-	-	-	-	3	326	...	...
Croatan township	714	540	32.2	711	-	2	1	-	-	385	214	79.9
East Lake township	112	88	27.3	112	-	-	-	-	-	67	42	59.5
Hatteras township†	2,783	1,333	108.8	2,722	20	5	27	9	11	1,379	620	122.4
Kennekeet township†	1,060	565	87.6	816	241	3	-	-	7	648	324	100.0
Nags Head township	4,971	3,328	49.4	4,408	546	5	2	10	17	3,676	1,974	86.2
Manteo town	902	547	64.9	684	216	2	-	-	4	497	214	132.2
Nags Head town	1,020	414	146.4	1,007	5	2	1	5	5	1,812	823	120.2
Hyde County	5,873	5,571	5.4	3,777	2,088	-	2	6	54	2,836	2,002	41.7
Currituck township	1,302	1,133	14.9	860	442	-	-	-	16	583	375	55.5
Fairfield township	582	541	7.6	315	266	-	1	-	-	243	190	27.9
Lake Landing township	2,217	2,377	-6.7	1,261	952	-	1	3	15	978	763	28.2
Lake Mattamuskeet (unorg).	16	21	-23.8	16	-	-	-	-	-	14	6	133.3
Ocracoke township	658	541	21.6	654	4	-	-	-	-	471	305	54.4
Swan Quarter township	1,098	958	14.6	671	424	-	-	3	23	547	363	50.7
Tyrrell County	3,975	3,806	4.4	2,418	1,550	3	-	4	14	1,766	1,371	28.8
Alligator township	477	482	-1.0	48	428	1	-	-	4	153	128	19.5
Columbia township	2,098	1,910	9.8	1,562	532	2	-	2	6	1,005	765	31.4
Columbia town	758	902	-16.0	369	389	-	-	-	-	345	345	-
Gum Neck township	474	523	-9.4	322	152	-	-	-	2	217	183	18.6
Scuppernong township	864	838	3.1	429	434	-	-	1	1	369	268	37.7
South Fork township	62	53	17.0	57	4	-	-	1	1	22	27	-18.5
Washington County	14,801	14,038	5.4	8,346	6,410	6	24	15	137	5,432	4,243	28.0
Lees Mills township	3,589	3,407	5.3	1,344	2,240	2	2	1	80	1,221	964	26.7
Roper town	795	649	22.5	215	577	1	2	-	25	262	207	26.6
Plymouth township	7,789	7,512	3.7	4,847	2,916	1	19	6	35	2,857	2,323	23.0
Plymouth town	4,571	4,774	-4.3	2,312	2,246	-	9	4	23	1,695	1,513	12.0
Scuppernong township	1,540	1,733	-11.1	1,068	464	3	1	4	10	650	508	28.0
Creswell town	426	633	-32.7	267	155	2	-	2	3	173	195	-11.3
Skinnersville township	1,883	1,386	35.9	1,087	790	-	2	4	12	704	448	57.1
TOTALS (Four-County Area)	38,026	30,410	-	27,009	10,875	27	66	49	261	21,040	12,673	-

altered by man's activities. The atlas is a compilation of existing data on the region that will aid in assessing the need for further specialized scientific studies to fill data gaps.

A key to proper use of land and water is an inventory of physical and biologic environments. The maps and text of this atlas provide information on land use and land cover, including biotic assemblages; waters, including artificial drainage systems and bathymetry; physical properties, including subaqueous sediments; active natural processes; and natural resources of Dare, Hyde, Tyrrell, and Washington Counties, in a manner amenable to long-range environmental planning and management. The atlas is organized to serve in two ways:

1) As a planning and management tool that can aid understanding of natural systems that shape the coast; and

2) As a standard, or baseline, of environmental conditions against which ongoing and evolving changes can be measured and evaluated in the future.

The atlas is intended to meet immediate State agency needs for information on the four-county area and to aid those agencies in making the decisions necessary to insure minimal disruption of environmental quality. Other groups and individuals such as county planners, engineers, lawyers, and local governmental organizations will also be able to utilize the atlas in their work. Environmental maps also provide a base from which coastal scientists can operate in gathering, interpreting, and updating technical data from many sources. In preparing the atlas, every effort was made to coordinate the classifications and systems used with those generally recognized or accepted by governmental agencies and experts in many fields.

Environmental Mapping and Archive Maps

For base maps, this atlas project has used the United States Geological Survey (USGS) 7 1/2 minute topographic quadrangle series (scale - 1:24,000 or 1 inch = 2,000 feet) (Figure 2). The entire geographical area of the atlas is covered by sixty-two quadrangles which have been indexed for easy reference. However, because only 59 of these topographic maps have been published, the Advance Print USGS Orthophotoquads were used as base maps for the remaining three quadrangles. Also, several special use environmental map series were developed for inclusion in the atlas. Four of these were compiled as mylar overlays to the topographic maps. These four map series are:

1. Physical Properties

    a. Detailed Physical Properties
    b. General Soil Associations
    c. First Colony Soil Data

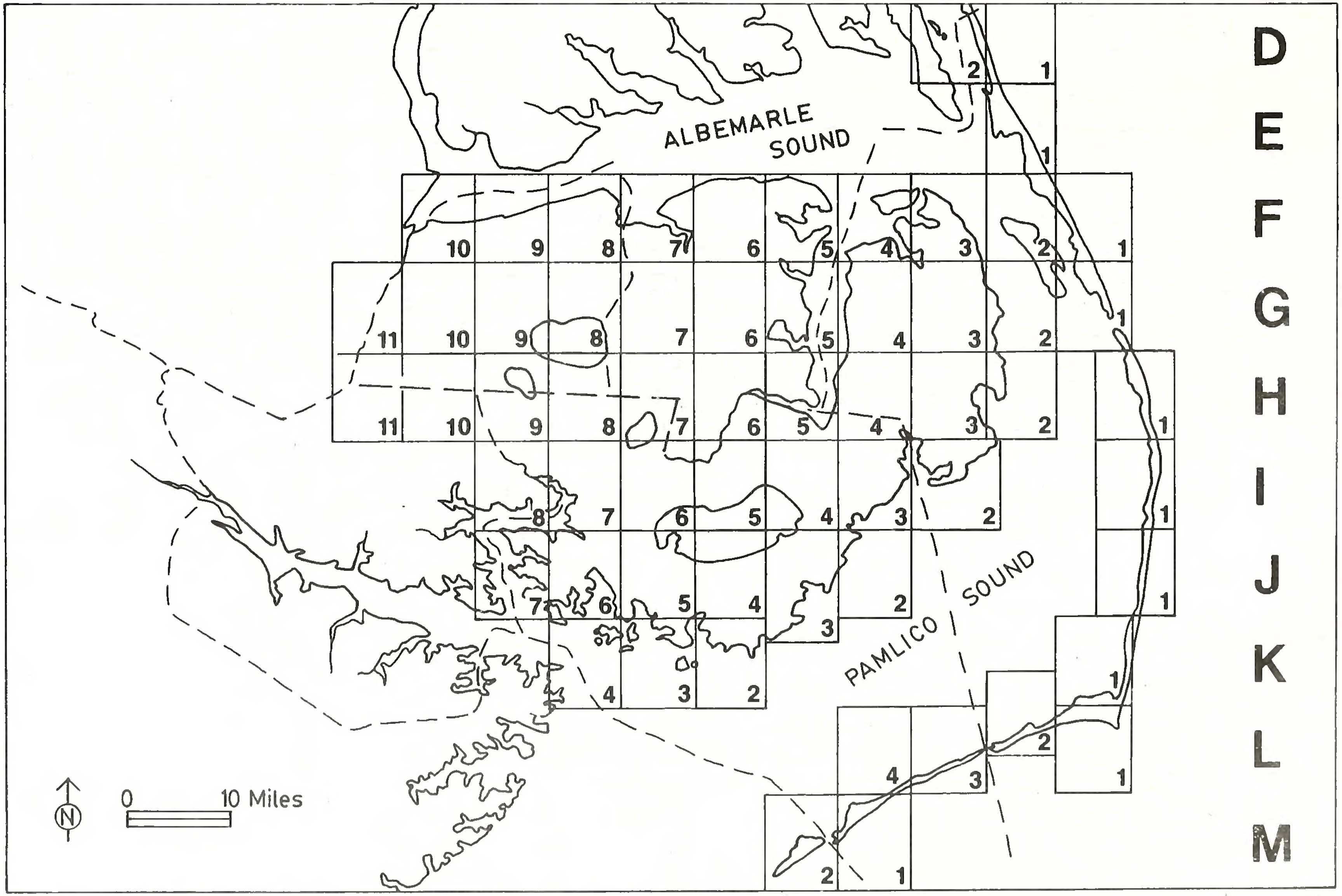


Figure 2. Index to USGS 7½ Minute Topographic Quadrangles (Base Maps) and Overlays.

2. Land Use and Land Cover (includes biotic assemblages)

3. Active Processes

4. Drainage and Bathymetry

Each archive overlay map is labeled with an index letter and number (such as F-1), the quadrangle name, the series title (such as Physical Properties), and a legend appropriate to the mapping units. A scale was not placed on the mylar overlays because each topo sheet has both a bar and a fractional scale. One topographic base map (I-3, Engelhard East) and the four map series overlays that accompany it have been reduced to page size and included in Appendix A for exemplary purposes (Plates I-IV, page A-1-A-4). Keys to the four map series are also included in Appendix A (pages A-5-A-10). Data for the exploratory oil wells are found in Appendix B.

Copies of all four series of archive Maps are located in the Office of Coastal Management, North Carolina Department of Natural Resources and Community Development, and in the Institute for Coastal and Marine Resources at East Carolina University. The Institute will provide copies of the overlay maps and the topographic (base) maps to any interested party for a minimal charge.

Because of the subject matter, one map was compiled at a smaller scale on a single mylar sheet. The title of this map is:

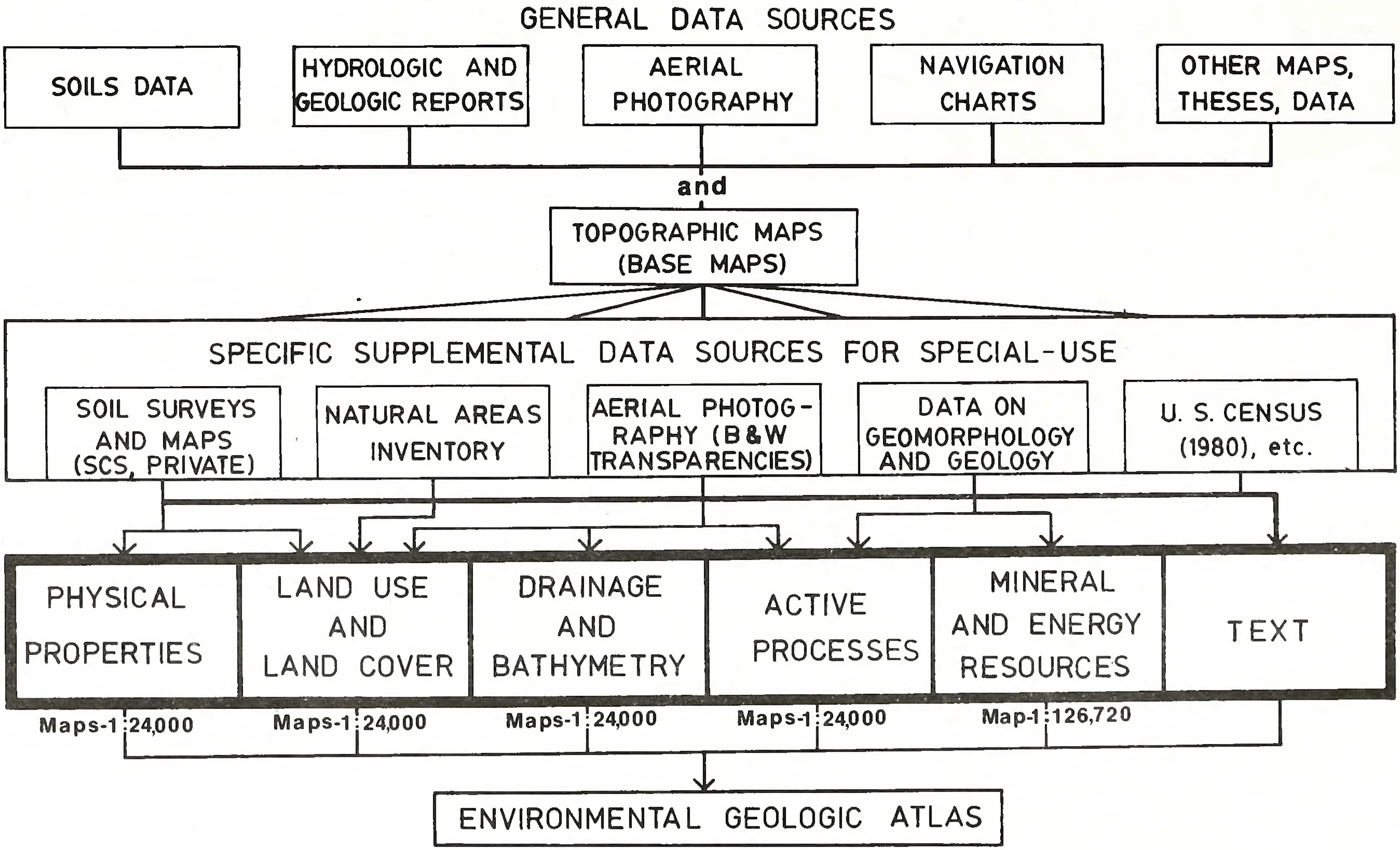
5. Mineral and Energy Resources

Mapping involved extensive use of aerial photographs, taken during either 1980 or 1981, and both published and unpublished data on the region. The project staff participated only in limited field work and aerial reconnaissance. General sources of data used in the project are shown in Figure 3. Specific data sources are cited in either the narrative or on the illustrations.

Using the Maps

The user of any of the overlay map series must first select the appropriate USGS 7 1/2 minute topographic quadrangle (base map) for the area of concern. All of the maps enclosed in the atlas portfolio are designed to be used as overlays to the USGS topographic maps. An index letter-and-number designation has been given each topographic quadrangle (and all corresponding overlays) for ease of selection (see index map, Figure 2, of the text or in portfolio).

The maps are designed so that the user can evaluate his particular needs and consult the proper map series. One example of such use might deal with a problem of landfill site location. By 1980, the approved 9-acre sanitary landfill in Washington County, northeast of Westover, was 95 percent full. It is estimated that the additional 14-acre expansion will be full in 7 years (Washington County Land Use Plan 1980). Thus, county planners and sanitation engineers will need to consider additional sites for solid waste disposal. Thus, these local officials should be able to evaluate and eliminate unsuitable sites through study of soil characteristics (Physical Properties Map Series) and current land use or cover (Land Use and Land Cover Map Series). They could decide on several possibly suitable areas and then, after consulting the local Soil Conservationist, select the most appropriate site. Data presented in the atlas should enable preliminary considerations and site eliminations to be made more quickly, with less loss of search-time hours and efficiency.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U. S. CENSUS (1980), etc.
PHYSICAL PROPERTIES
LAND USE AND LAND COVER
DRAINAGE AND BATHYMETRY
ACTIVE PROCESSES
MINERAL AND ENERGY RESOURCES
TEXT
Maps-1:24,000
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Map-1:126,720
ENVIRONMENTAL GEOLOGIC ATLAS

Figure 3. Sources and Flow of Data for the Environmental Geologic Atlas.

GENERAL SETTING

The Coastal Plain of North Carolina consists of two natural divisions; an inner part that is generally well-drained and gently rolling, and an outer portion that is generally poorly drained, lower lying, and swampy.

Elevation

All the the area east of Plymouth in Washington County lies in the Outer Coastal Plain, an area also called the Tidewater Region (Stuckey 1965). Generally, elevations in this area are less than 20 feet, and much of the eastern part is less than 5 feet above mean sea level (Heath 1975). The only parts of this area above 50 feet in elevation are on the Dare County portion of the Outer Banks; specifically, 1) the vegetated dunes at Duck, 2) nonvegetated dunes between Kill Devil Hill and Nags Head, including Collington Island (max. elev. 150 feet), 3) relict beach ridges at Hatteras Island (max. elev. 60 feet), and 4) bluffs on the northeast side of Roanoke Island (max. elev. 70 feet).

Streams

Only two major streams in the peninsula region have their sources west of the Coastal Plain in the Piedmont Plateau physiographic province. The Roanoke River enters North Carolina in Warren County, flows across the Coastal Plain, and empties into Albemarle Sound just west of Plymouth. The Tar River rises in Person County, flows across the Coastal Plain to Washington in Beaufort County, and becomes the Pamlico River. The other major streams in the area are the Pungo River, the Scuppernong River, and the Alligator River. These are short coastal plain streams that become estuaries in their lower reaches. Numerous short, slow flowing coastal tributaries empty into these rivers (Figure 4).

Prior to the construction of canals in the study area, overland runoff must have been a considerable factor in the water budget. However, the Geological Survey streamflow-data collection program in North Carolina had about 168 stations in 1974, but none were located in the Outer Coastal Plain seaward of the Suffolk Scarp. There are several reasons for this seeming disparity, including problems presented by slow velocities and tidal fluctuations common to streams of the Outer Coastal Plain (Heath 1975). Because streamflow data for the study area is scarce, overland runoff can best be estimated as the difference between precipitation and other water budget items (Heath 1975):

Table 2. Estimation of Overland Runoff (Heath 1975).

Precipitation		51.0 inches
Evapotranspiration	36.0 inches	
Groundwater Discharge . . .	0.5 inches	
	Subtotal	36.5 inches
Overland Runoff (estimation by difference)		14.5 inches

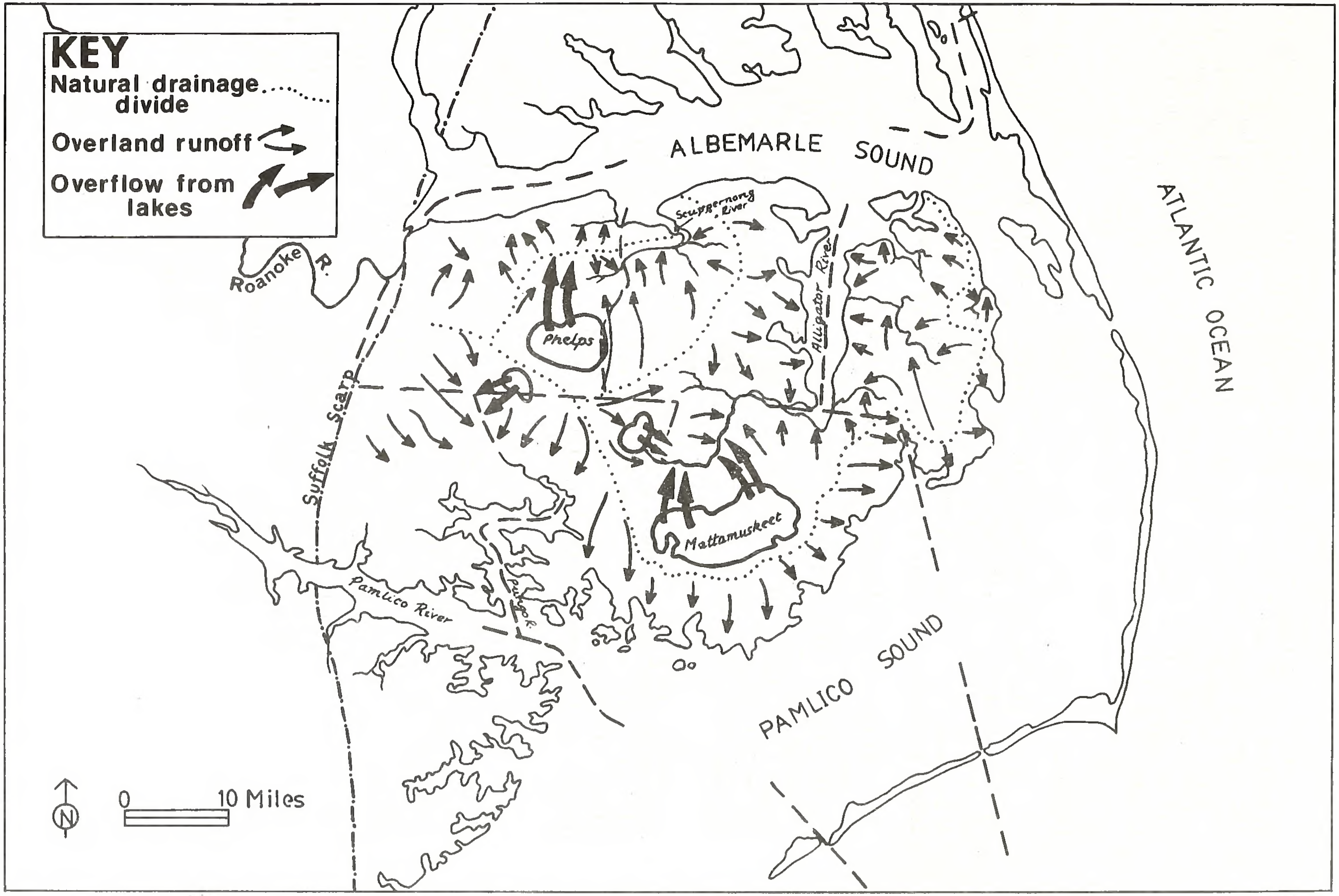


Figure 4. Drainage Divides and Probable Paths of Overland Runoff Prior to Artificial Drainage Systems (adapted from Heath 1975).

Prior to construction of the extensive system of canals and ditches, overflow runoff probably moved north from Lake Phelps to the Scuppernong River and from Mattamuskeet north to the Alligator. Most overland flow moved out from the natural drainage divides towards the edge of the peninsula or inland streams (Figure 4). The effect of the extensive system of artificial drainage canals on overland runoff is considered in the section of Drainage and Bathymetry (Pages 71 and 73).

Lakes

The peninsula is the site of several lakes: Phelps, on the Washington-Tyrrell County line; Pungo, on the Washington-Hyde County line; and New (Alligator) and Mattamuskeet in Hyde County. Lake Mattamuskeet is the largest of these with a surface area of 66.7 square miles (Coastal Zone Resources Corp. 1976). These lakes are very shallow; average depths range from 2.5 to 5 feet (Figure 1).

Prior to construction of artificial drainage systems, the lakes on the Albemarle-Pamlico peninsula were very inaccessible because of the densely vegetated swamps and pocosins surrounding them. Although settlers began to move into the region that now constitutes northern Washington and Tyrrell Counties about 1700, they did not find Lake Phelps until 1755. Yet Lake Phelps is only 10 miles inland (Heath 1975). Lake Mattamuskeet is now a National Wildlife Refuge; Lake Phelps is part of Pettigrew State Park, a recreational area.

Modification of the hydrologic conditions of the peninsula began in 1787 when a 20-foot wide canal, 6 feet deep and 6 miles long, was constructed from the northeast corner of Lake Phelps to the Scuppernong River (Sharpe 1966). Thus, man began to alter the environment in the study area nearly two centuries before he became concerned with the possible impact of his activities (Heath 1975).

The origin of the peninsula lakes has been widely debated. Shaler (1890) hypothesized that, like Lake Drummond in the Great Dismal Swamp, the lakes of the Albemarle-Pamlico peninsula are areas not yet infilled with swamp deposits. Sharpe (1966) relates the popular and somewhat romantic Indian legend that Lake Mattamuskeet was formed by a great peat fire that lasted for 13 moons. Or perhaps dissolution of a shelly carbonate unit in the underlying sediments caused collapses or sinks that later became lakes (Oaks 1965, referring to Lake Drummond). It seems reasonable that the peninsular lakes occupy relatively higher areas between valleys eroded into the pre-peat landscape. If this is so, then the buildup of peat in surrounding lower areas and the rise of the water table could have contributed to formation of the lakes by restricting drainage (Heath 1975).

Albemarle Sound and Adjacent Open-Water Areas

Albemarle Sound covers an area of approximately 480 square miles and contains some 233 billion cubic feet of water. The sound is a drowned river valley estuary extending eastward from the confluence of the Chowan and Roanoke Rivers to the Outer Banks (Figure 13). Open-water areas of lateral tributaries combined with surface areas of Currituck, Croatan, and Roanoke Sounds bring the total to 933 square miles (Giese et al. 1979).

Albemarle Sound has an average depth of less than 18 feet and a maximum depth of 30 feet (Figure 5). The central portion of the sound from Edenton to the Alligator River contains a broad, flat-bottomed trough with depths in excess of 18 feet. Seaward of the Alligator River the width of the sound increases, and the bathymetry rises above the 18-foot contour. Textures of bottom sediments grade from predominantly clays in the trough to fine sands along the flanks and the lower portion of the sound (Pels 1967) (Figure 6).

At the mouth of the Albemarle Sound, below the 6-foot depth contour, the basin splits into three branches that connect the sound with Currituck, Roanoke, and Croatan Sounds. In Croatan Sound, maximum depths of about 18 feet occur in several discontinuous troughs within its northern and southern extremities (Figure 7). Depths vary from 8 feet to 14 feet in the central portion of the sound. Maximum depths of 6 feet to 9 feet occur in Roanoke and Currituck Sounds, respectively. Gravelly sands and shell gravel are dominant in the deep troughs of Croatan Sound, with fine to very fine sand covering much of the remaining sections of Croatan and Roanoke Sounds (Riggs and O'Connor 1974) (Figure 8).

Outflow from Albemarle Sound enters Pamlico Sound through Croatan and Roanoke Sounds, where it is discharged into the ocean through Oregon, Hatteras, and Ocracoke Inlets. Seventy-five to 85 percent of the flow from Albemarle to Pamlico Sound passes through Croatan Sound, while less than 25 percent of the flow passes through Roanoke Sound (Jarrett 1966; 74th Congress 1935). The proportionally greater volume of freshwater discharged through Croatan Sound results in observed trends of erosion in Croatan Sound and deposition in Roanoke Sound (Riggs and O'Connor 1974).

The range of semidiurnal astronomic tides throughout Albemarle Sound is less than 0.5 feet. The remote connection of the sound to the ocean combined with freshwater outflow are responsible for the low periodic tide range observed in the sound. The periodic tide range is somewhat greater at the mouths of estuarine tributaries in the Albemarle Sound system and increases headward due to funneling effects of decreasing dimensions in an upstream direction. For example, on December 6, 1974, the periodic tide range in the Chowan River increased from 0.2 feet at the mouth to 0.7 feet near Eure, 45 miles upstream (Giese et al. 1979).

Short-term, wind-driven currents dominate flow and water levels in Albemarle Sound and the adjoining open-water areas of Croatan and Roanoke Sounds. The seasonal range of water levels induced by wind-driven currents on Albemarle Sound is about 0.8 feet near Edenton at the mouth of the Chowan River (Daniel 1977). Wind-induced current velocities ranging from 0.5 knots to 1.6 knots in Croatan and Roanoke Sounds have been measured (Singer and Knowles 1975). Varying patterns of wind-induced flow conditions in Croatan and Roanoke Sounds can be observed in Figure 9.

On a long-term basis, net flow into Albemarle Sound is dominated by freshwater inflow because the effects of winds blowing from various directions tend to cancel each other out over time. This is also true for Pamlico Sound. Average inflow to Albemarle Sound is about 17,000 ft^3/sec, which drains from a total area of some 18,359 square miles (Table 3). The average period required for water stored in Albemarle Sound to be completely flushed and replaced by fresh water is about five months (calculated from hydrologic data in Giese et al. 1979).

Periods of high freshwater inflow to Albemarle Sound usually reflect the typical peak flow period of many North Carolina streams, with maximum average freshwater inflow in February and minimum freshwater inflow in October. The effect of evaporative water loss on the gross water budget of the sound is reflected in lower outflow values for June (Table 3).

Average surface salinities are lowest in March following high freshwater inflow from January through March. Surface salinities reach a maximum in December following low freshwater inflow from June through September (Figure 10 A & B).

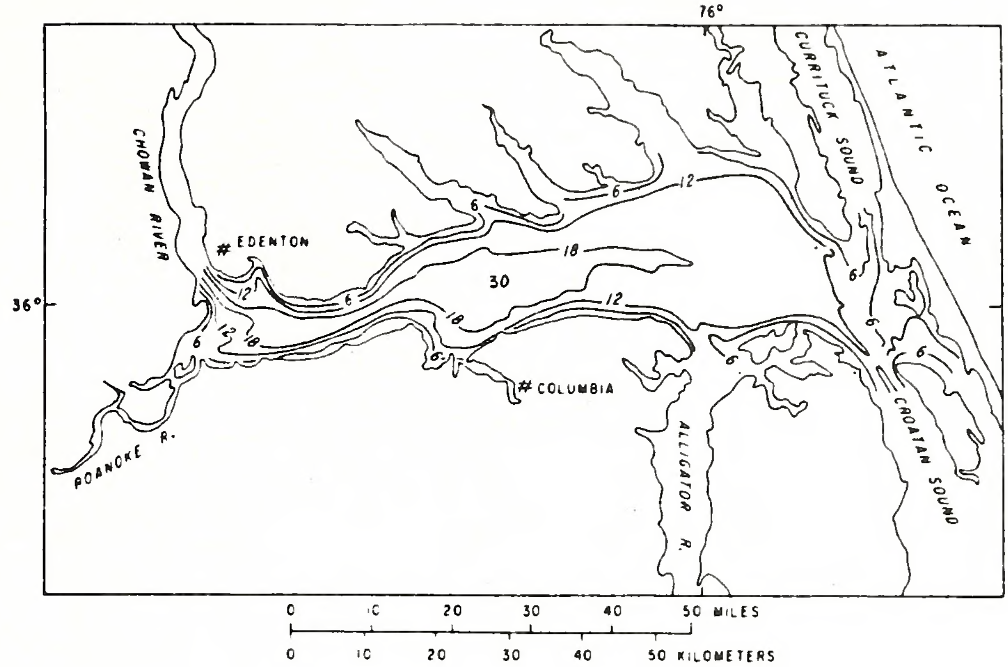


Figure 5. Bathymetry of Albemarle Sound (from Giese et al. 1979, after Pels 1967).

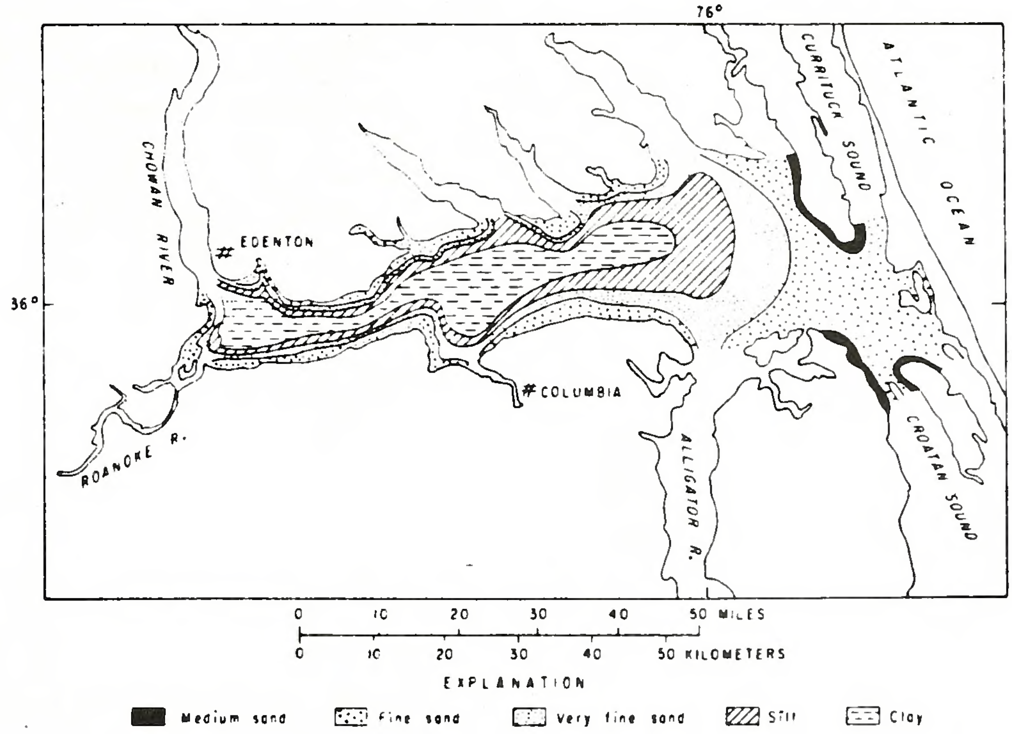


Figure 6. Texture of Bottom Sediments in Albemarle Sound (from Giese et al. 1979, modified from Pels 1967, after Folger 1972).

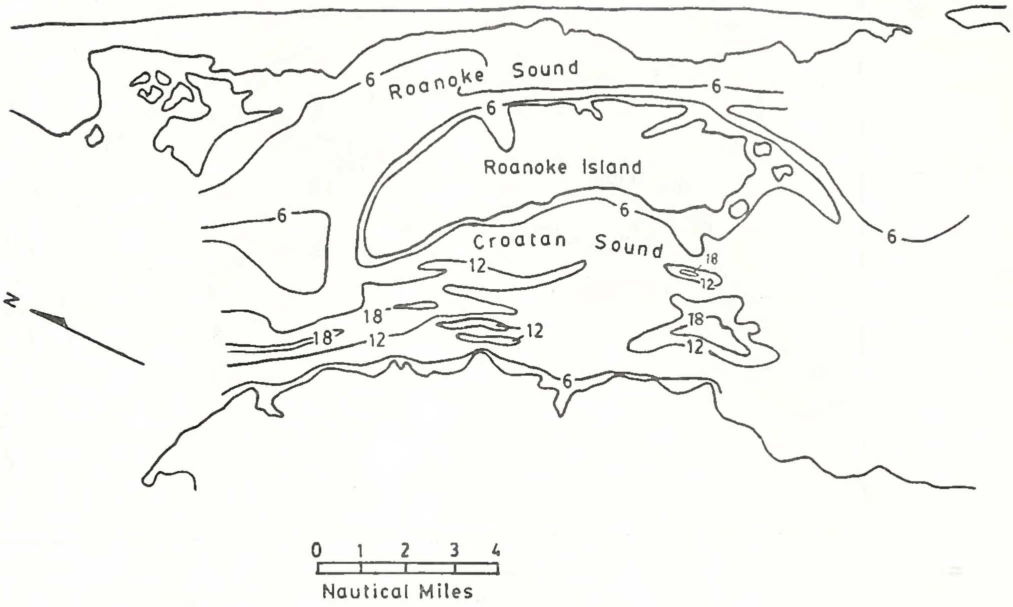


Figure 7. Bathymetry of Croatan and Roanoke Sounds (modified from Riggs and O'Connor 1974)

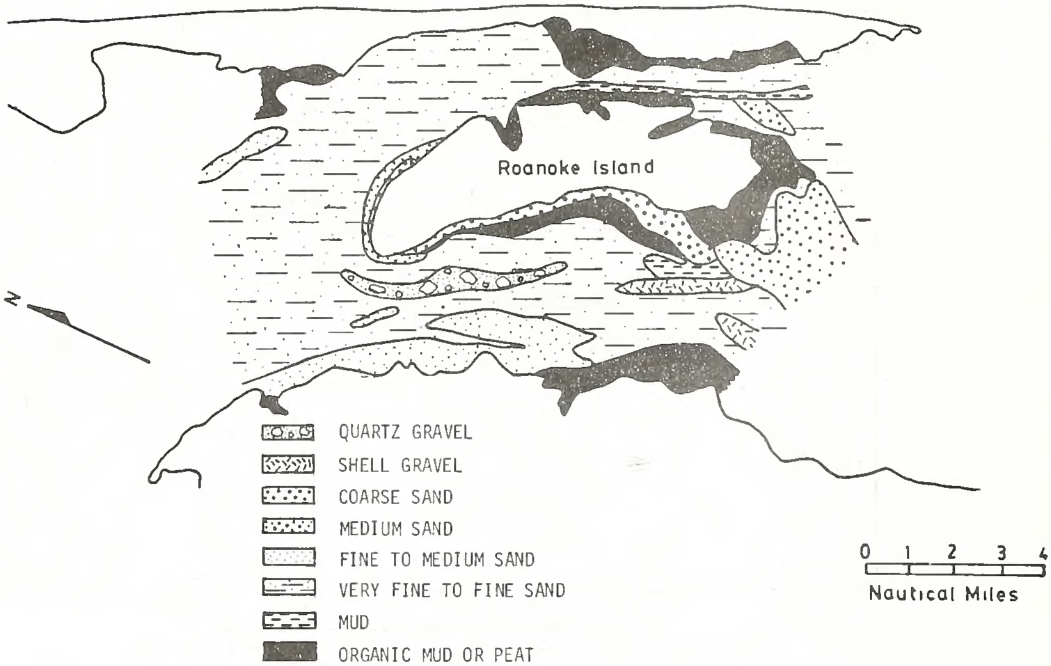


Figure 8. Texture of Bottom Sediments in Croatan and Roanoke Sounds (modified from Riggs and O'Connor 1974).

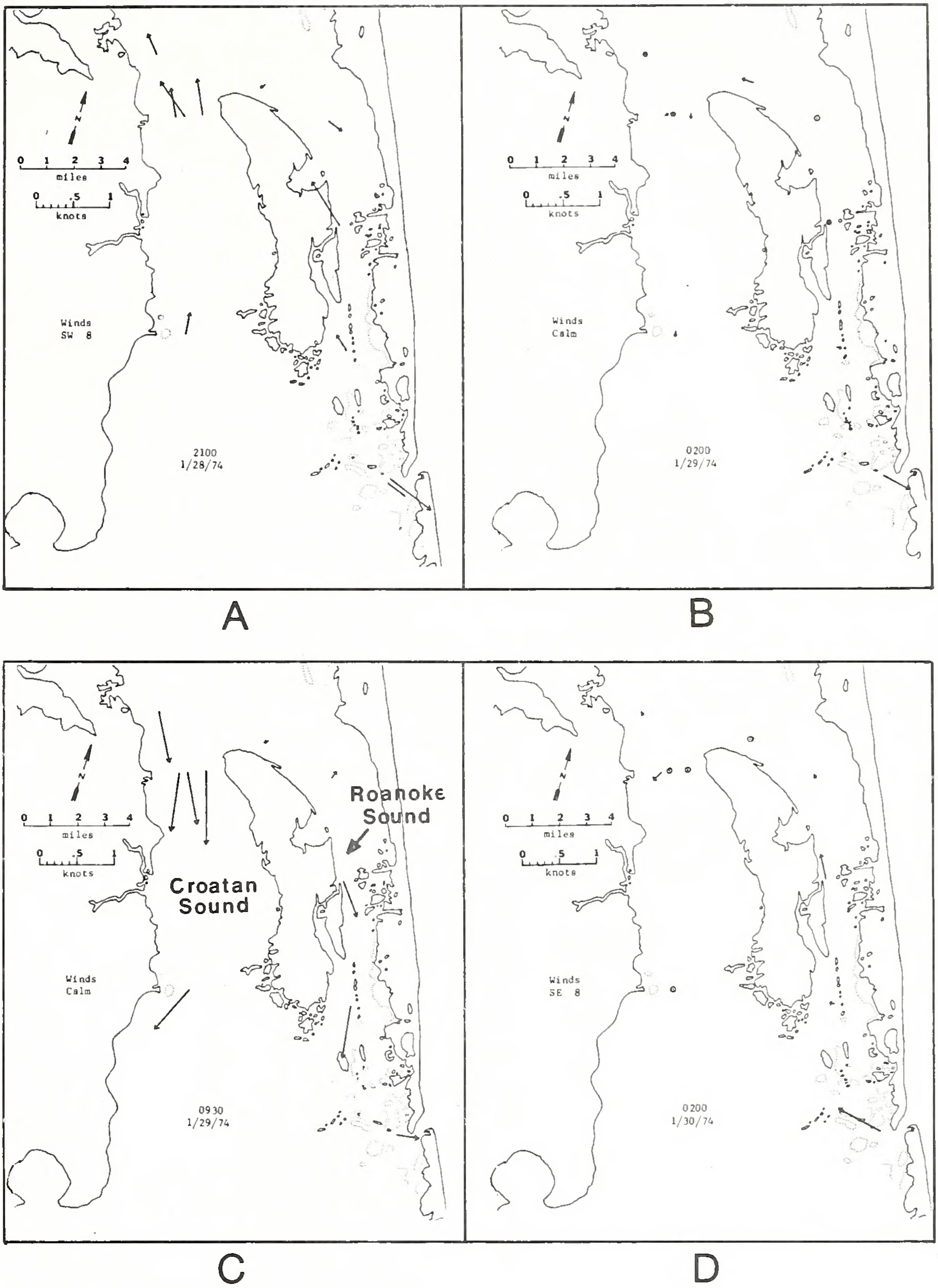


Figure 9. Patterns of Varying Wind-Induced Flow Conditions in Croatan and Roanoke Sounds (from Singer and Knowles 1975).

Table 3. Monthly and Annual Gross Water Budget for Albemarle Sound (from Giese *et al*. 1979)

Element of Gross water budget	Drainage area in square miles	Average monthly and annual values, in cubic feet per second												
		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average annual
A. Precipitation on Albemarle Sound and associated open-water areas	933	2,800	3,400	2,900	2,500	2,800	3,600	5,400	5,000	4,300	2,500	3,000	2,600	3,400
B. Evaporation from Albemarle Sound and associated open water areas	933	1,000	1,700	2,200	3,400	3,900	4,200	4,100	3,500	2,800	1,800	1,400	900	2,600
C. Inflow from Chowan River Estuary at mouth near Edenton	4,943	6,500	9,100	8,600	6,600	3,700	2,600	3,000	3,500	3,000	2,200	2,500	4,400	4,600
D. Inflow from Roanoke River Estuary at mouth near Plymouth	9,666	10,000	12,000	10,000	11,000	10,000	8,500	8,000	7,500	6,500	6,500	7,500	8,300	8,900
E. Inflow from land areas not included in above elements	2,817	4,200	5,900	5,600	4,300	2,400	1,700	1,900	2,200	2,000	1,400	1,600	1,300	2,900
F. Total outflow of Albemarle sound into Pamlico Sound $F = A - B + C + D + E$	18,359	23,000	28,000	25,000	21,000	16,000	12,000	14,000	15,000	13,000	11,000	13,000	16,000	17,000

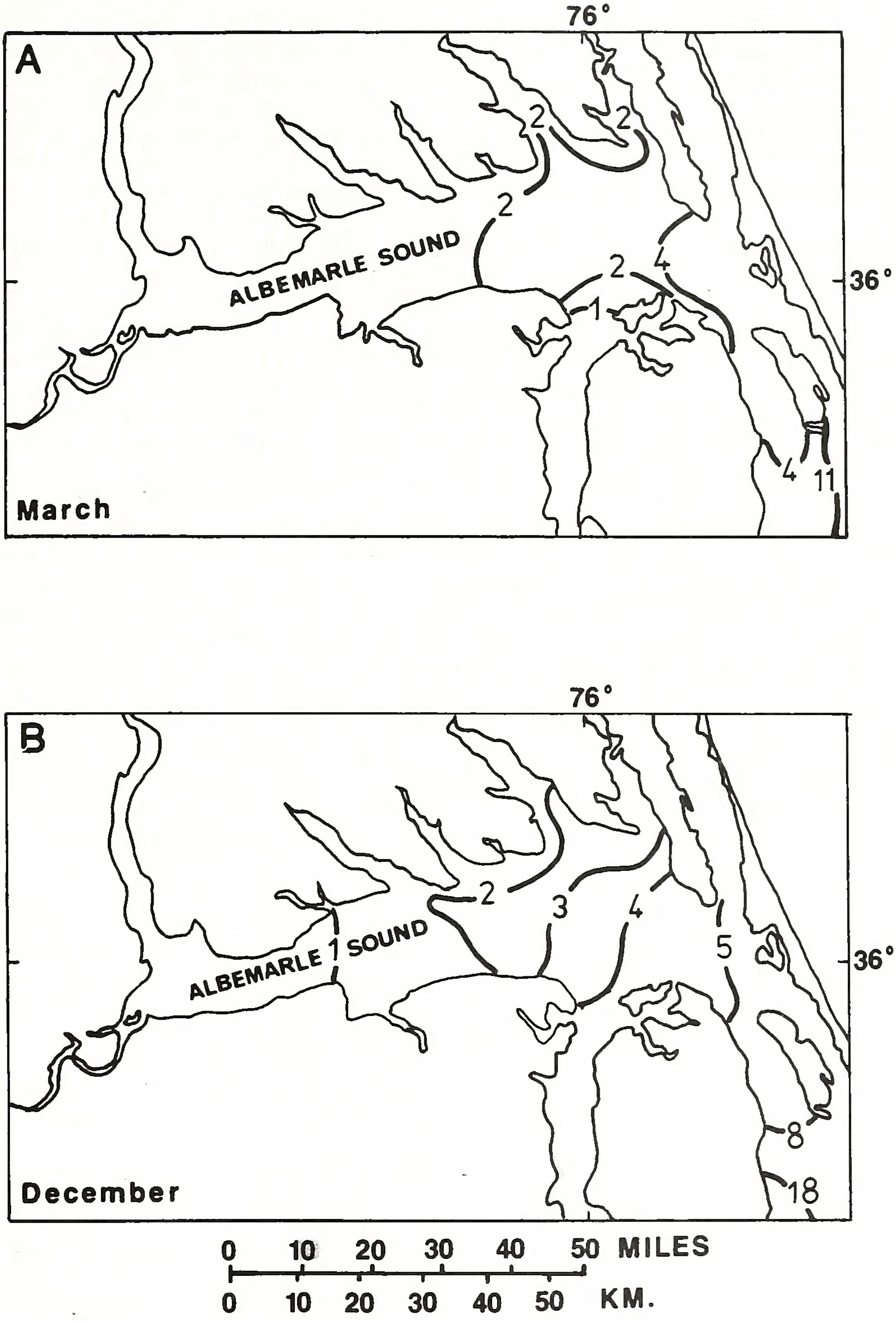


Figure 10. Average Surface Salinities of Water in Albemarle Sound and Vicinity (from Giese et al. 1979, modified from Williams et al. 1967) (Salinity —3—, in grams per kilogram).

Pamlico Sound

Pamlico Sound covers an area of approximately 2,060 square miles and contains 920 billion cubic feet of water. It is bounded by the drowned river valley estuaries of the Tar-Pamlico and Neuse-Trent River systems to the southwest, by the peninsula to the west, and by the Outer Banks to the east (Figure 13). It is the largest sound formed behind a barrier-island strand on the Atlantic Coast of the United States (Giese et al. 1979).

Pamlico Sound has an average depth of 16 feet and contains a "y"-shaped basin with maximum depths of 26 feet at the confluence of the Neuse and Pamlico River. A broader basin with a maximum depth of 24 feet occurs in the central portion of the sound. A central lagoon shoal separates the two basins and extends across Pamlico Sound from Ocracoke Inlet to Bluff Point (Figure 11). Distribution of bottom sediments corresponds closely to the bathymetry of Pamlico Sound (Figure 12). Fine sands cover much of the sound bottom with silts dominant in basins below the 18-foot contour. Medium sands are confined to shoals, flood tidal deltas, and washover fans (Pickett 1965).

Pamlico Sound is connected with the ocean through Oregon, Hatteras, and Ocracoke Inlets (Figure 1). This limited access combined with the broad expanse of the sound results in astronomic or ocean tides being significantly dampened. Tide tables published by the National Ocean Survey estimate the mean periodic tide range offshore of Cape Hatteras as 3.6 feet, while the tidal range at Oregon and Hatteras Inlets is listed as 2.0 feet. The mean periodic tide range within Pamlico Sound is estimated as 0.2 feet. Periodic tide range is considerably greater in the narrow river-estuaries tributary to Pamlico Sound, due to the funneling effect of decreasing channel dimensions in the upstream direction (Roelofs and Bumpus 1953, Giese et al. 1979). For example, the mean periodic tide range at the mouth of the Pamlico River is about 0.5 feet and increases to approximately one foot at Washington (Giese et al. 1979).

On a short-term basis, wind-driven currents often dominate flow and water levels in the sound and adjoining estuaries (Giese et al. 1979, Singer and Knowles 1975). The large surface area of Pamlico Sound encourages wind setup over long fetches. Current velocity and water levels can be further amplified within adjoining estuaries by funneling effects. The wind-induced tide range has been estimated at 2 feet (Marshall 1951). However, in northern Pamlico Sound, setups of 2.5 feet and 9.8 feet have been estimated for southerly winds of 20 and 40 knots, respectively (Roelofs and Bumpus 1953).

Average annual inflow to Pamlico Sound is about 31,700 ft^3/sec, which drains from a total area of 28,820 square miles (Table 4). At this rate, water stored in Pamlico Sound would be completely flushed into the ocean in 11 months. Maximum average freshwater inflow to Pamlico Sound occurs between January and April, with the highest freshwater inflow recorded in February. Minimim net freshwater inflow does not occur in September, October, and November as is the case for many North Carolina streams, but in June when evaporation rates are greatest. Evaporative water loss resulting from the large surface area and relatively low freshwater inflow rates is a significant factor in the annual gross water budget (Giese et al. 1979).

Average surface salinity in Pamlico Sound reflects seasonal variations of freshwater inflow, although short-term, wind-induced currents may obscure seasonal salinity variations (Woods 1967, Giese *et al*. 1979). Average surface salinities are lowest in April, following peak freshwater inflow from February through April (Figure 13). Surface salinities reach a maximum in December after a period of low freshwater inflow from June through November (Figure 14). Seasonal surface salinity differences of 4 to 6 grams per kilogram are observed at the mouths of major estuaries, while seasonal salinity fluctuations of 0-2 grams per kilogram are observed in the vicinity of ocean inlets (Giese *et al*. 1979).

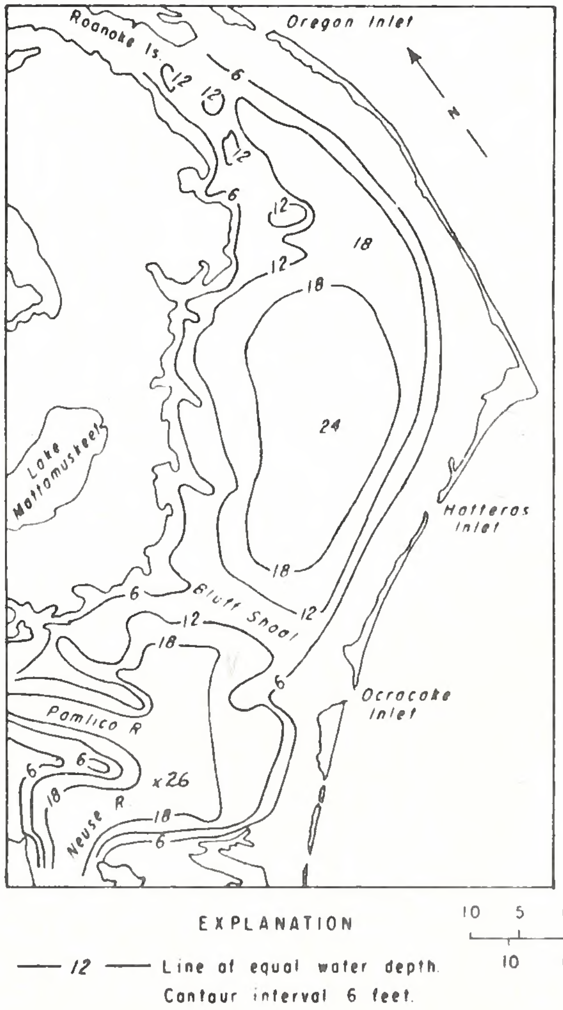


Figure 11. Bathymetry of Pamlico Sound (from Giese et al. 1979, after Pickett 1965).

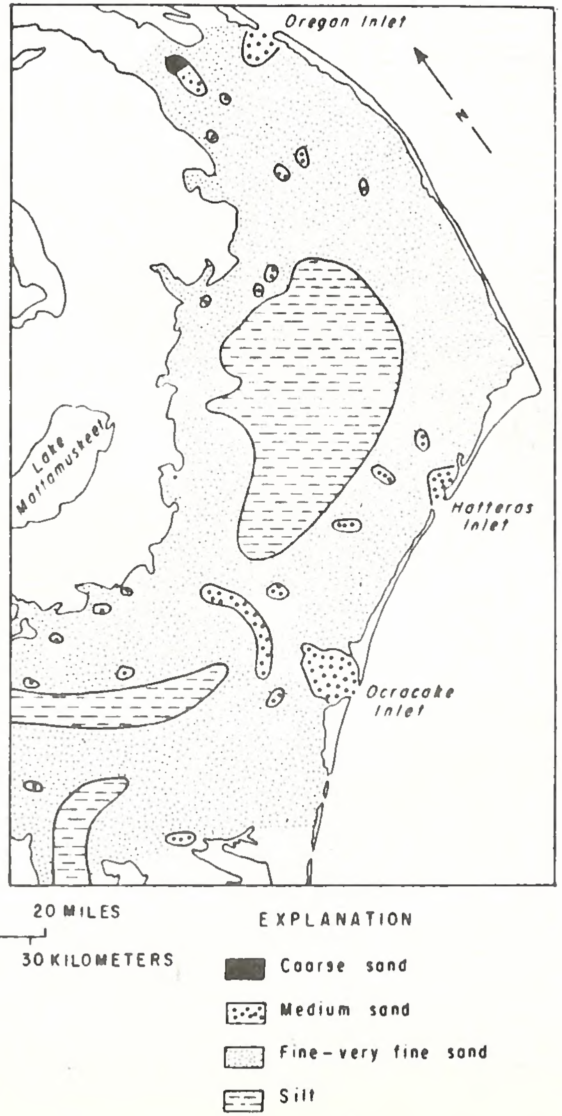


Figure 12. Texture of Bottom Sediments in Pamlico Sound (from Giese et al. 1979, from Folger 1972, after Pickett 1965).

Table 4. Monthly and Annual Gross Water Budget for Pamlico Sound (from Giese *et al*. 1979)

Element of Gross water budget	Drainage area in square miles	Average monthly and annual values, in cubic feet per second												
		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average annual[1]
Precipitation on Pamlico Sound	2,060	6,780	7,930	6,620	5,380	6,590	9,340	12,600	12,100	10,800	6,710	7,080	7,040	8,250
Evaporation from Pamlico Sound	2,060	2,330	3,310	4,900	7,530	8,590	9,320	10,000	7,680	6,110	4,080	3,000	1,990	5,740
Freshwater inflow to Pamlico Sound from land areas tributary to Pamlico Sound	10,460	17,000	21,600	19,100	13,200	11,300	6,220	8,940	10,900	8,530	7,900	8,240	11,100	12,000
Inflow from Albemarle Sound to Pamlico Sound	18,360	22,800	28,300	25,000	21,300	15,500	12,200	14,200	14,700	13,100	10,700	13,300	15,600	17,200
Net inflow to Pamlico Sound (or outflow to the ocean)	30,880	44,200	54,500	45,800	32,400	24,800	18,400	25,700	30,000	25,300	21,200	26,600	31,800	31,700

[1] Rounded.

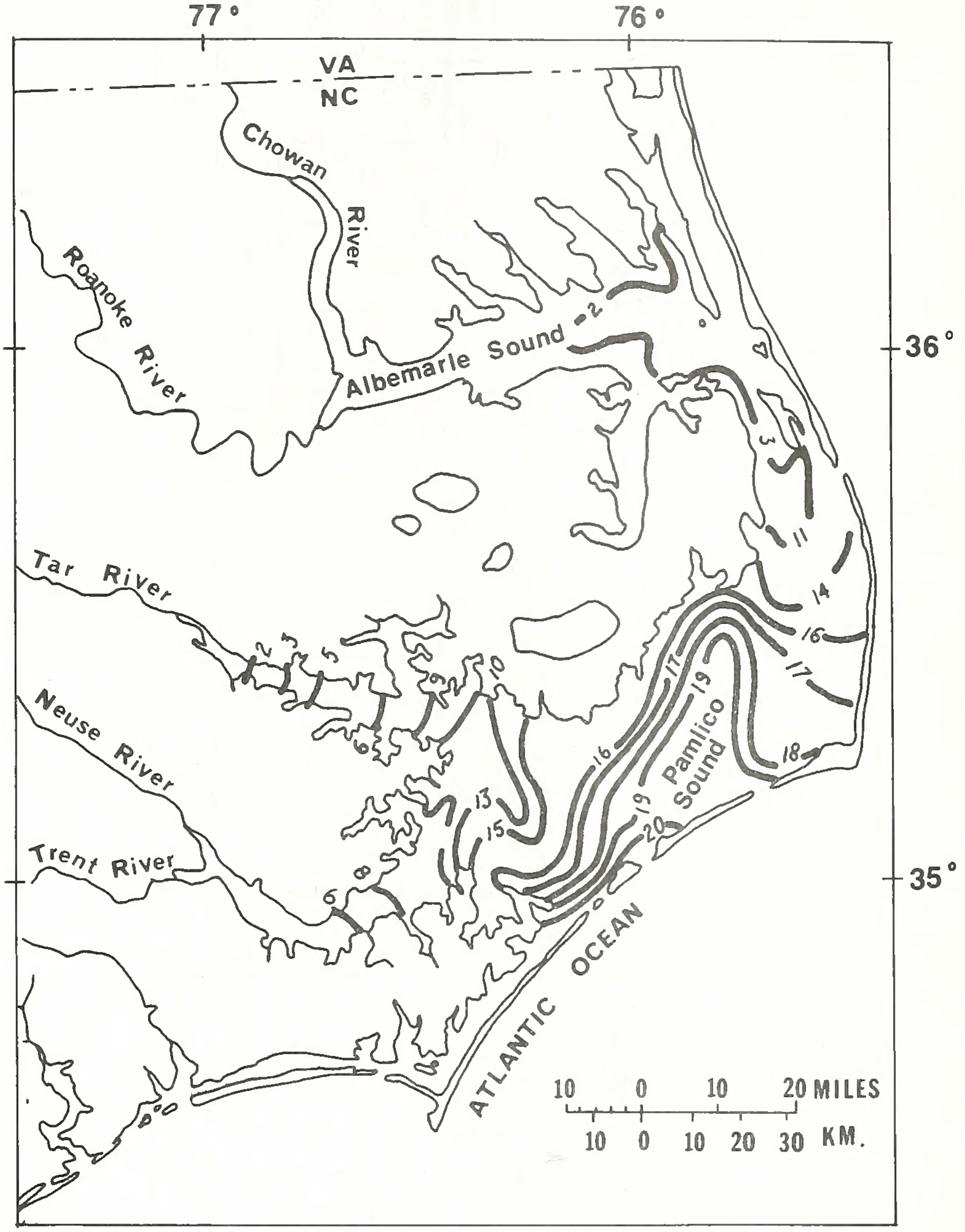


Figure 13. Average Surface Salinity of Water in Pamlico Sound and Vicinity for April (from Giese *et al.* 1979, modified from Williams *et al.* 1967) (Salinity 15, in grams per kilogram).

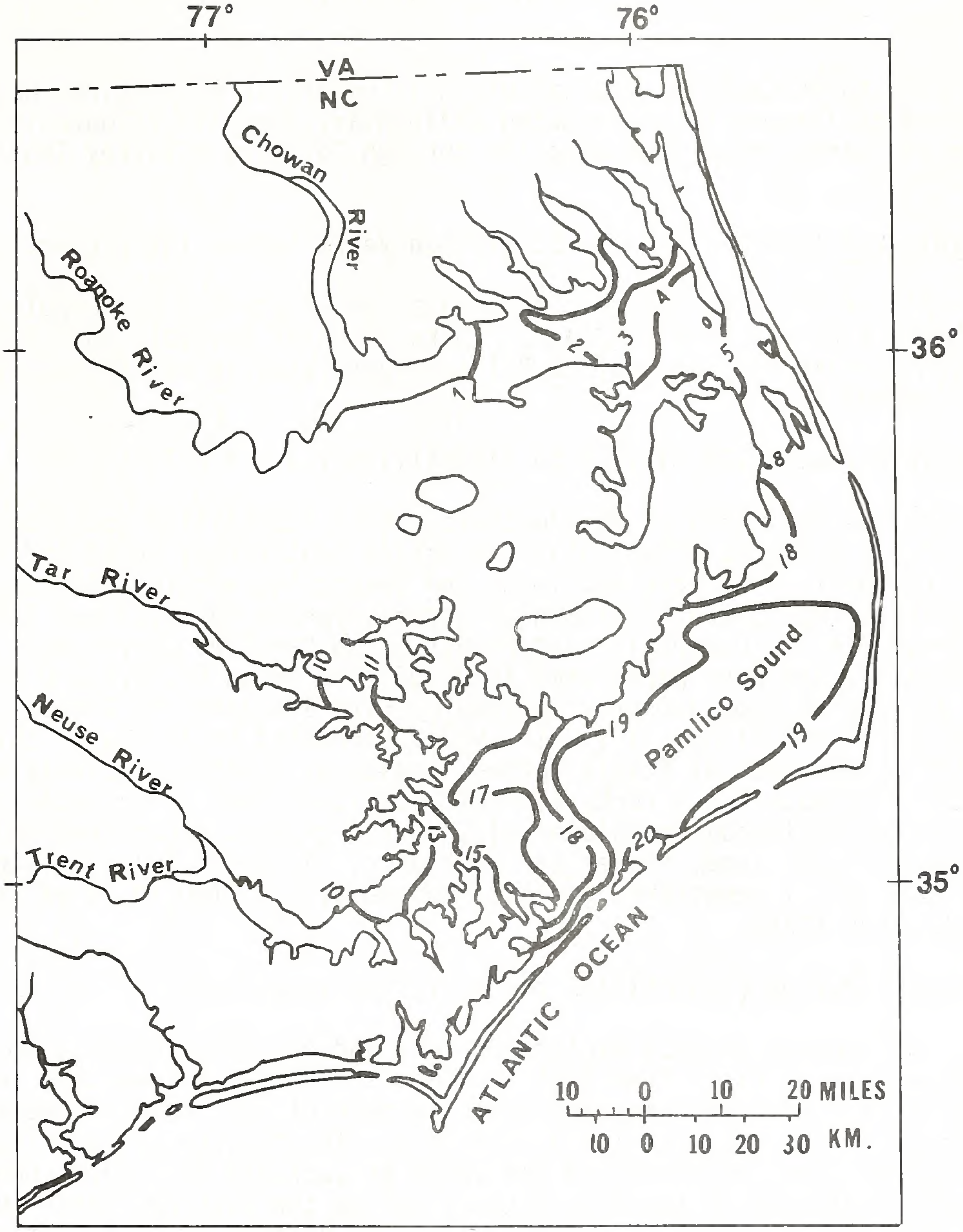


Figure 14. Average Surface Salinity of Water in Pamlico Sound and Vicinity for December (from Giese et al. 1979, adapted from Williams et al. 1967) (Salinity 16, in grams per kilogram).

GEOLOGIC HISTORY

The North Carolina Coastal Plain is underlain by a thick, wedge-shaped sequence of largely unconsolidated sedimentary deposits (Figure 15). In age, these sediments range from Jurassic through Tertiary (Stuckey 1965).

Mesozoic Era (∿190 million to 65 million years before the present (B.P.))

Middle and Late Mesozoic sediments are widespread but deeply buried on the North Carolina Coastal Plain. Rocks of Early Mesozoic age (Triassic, 190 million to ∿160 million years B.P.) are found only in basinal structures of the Piedmont.

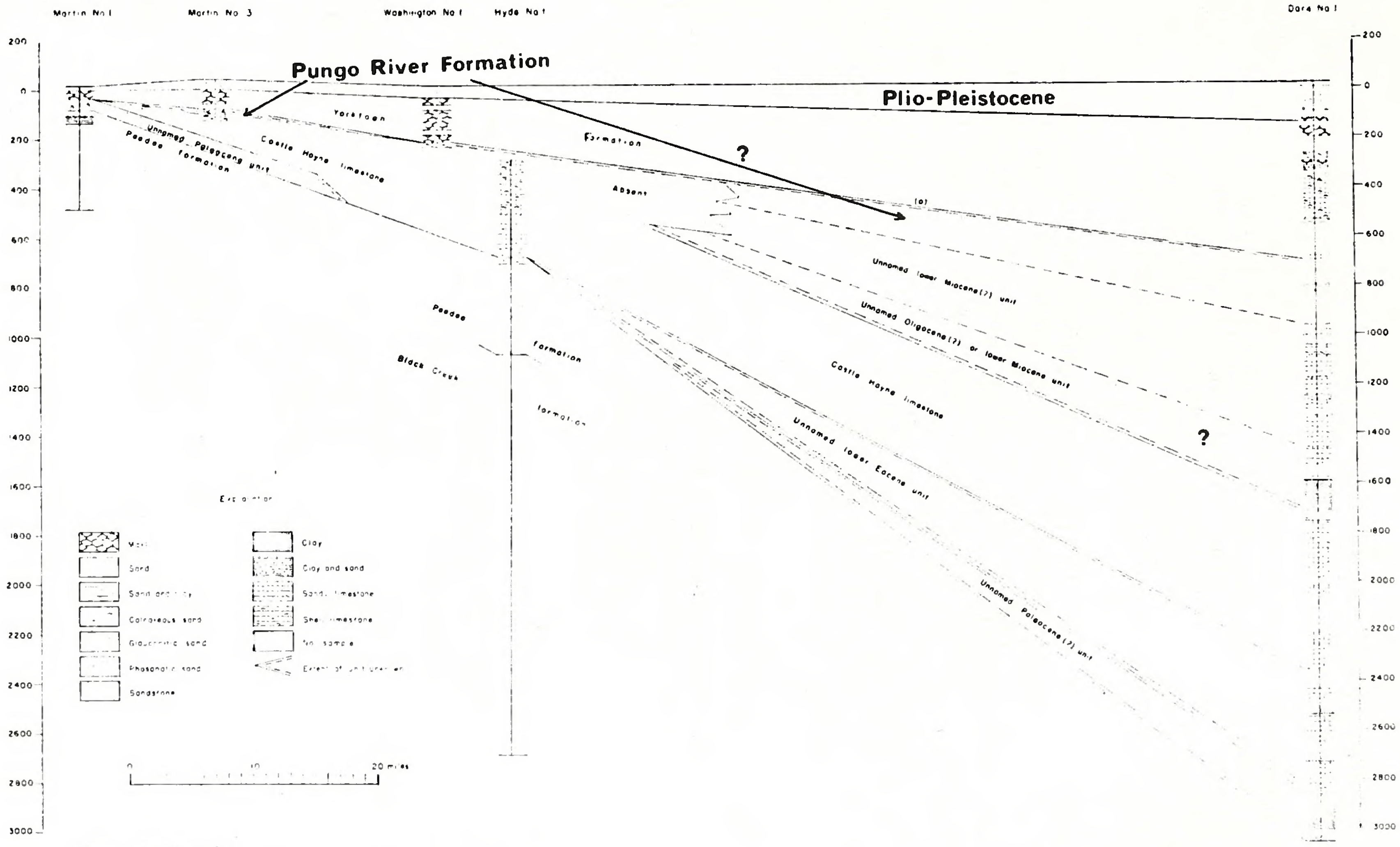
Jurassic Period (∿160 million to 135 million years B.P.)

At the beginning of the Jurassic, about 160 million years ago, all of present day North Carolina, plus the entire Continental Shelf off the North Carolina coast, was above sea level and undergoing erosion (Stuckey 1965). Jurassic sediments are not known to occur anywhere in North America east of the Great Plains, except in easternmost North Carolina where rocks of probable Jurassic age were penetrated at 8,500 feet in an exploratory oil and gas well drilled at Cape Hatteras in 1945 by Esso Standard Oil Company (Cape Hatteras Light Well No. 1) (Swain 1952). Jurassic sediments in this well consist of 650 feet of fossiliferous limestone, sometimes dolomitic or oolitic. Beneath these rocks lie 728 additional feet of probable Jurassic age non-fossiliferous, conglomeratic, coarse-grained sandstones and arkoses, interbedded with sandy shales and mudstones. At 9,878 feet the Cape Hatteras Light Well No. 1 penetrated granitic basement, presumed to be of Precambrian age (Stuckey 1965).

Cretaceous Period (135 million to 65 million years B.P.)

As a result of such exploratory gas and oil wells drilled in the North Carolina Coastal Plain from 1945 to 1960, it was determined that sediments of Early to Late Cretaceous age underlie much of the northern two-thirds of the region, including the peninsular area. The absence of Tuscaloosan age (Late Cretaceous) sediments to the south of Jacksonville, North Carolina, suggests that a NW-SE trending feature called the Cape Fear Arch functioned as a structural control on the thickness and distribution of Cretaceous deposits in the Coastal Plain (Spangler 1950; Legrand 1955; Stuckey 1965).

Well data indicate that a basin, or geosyncline, existed in the crystalline floor northeast of the Cape Fear Arch during Early Cretaceous times (Brown 1959). This basin deepened to the east and was evidently a subsidiary embayment of the major geosynclinal province to the east and north of present-day North Carolina (Stuckey 1965). Fossiliferous sandstones, limestones, limey clays, and clays of Early Cretaceous age and marine origin reach a thickness



Geologic cross section C-C'

The vertical scale is greatly exaggerated for the purpose of illustrating the rock units

The slope of line (a) is actually about 6 feet per mile

Figure 15. NW-SE Geologic Cross Section (C-C') (adapted from Brown 1958), see Figure 1 for section location.

of over 2,800 feet in the Cape Hatteras Light Well No. 1 (Swain 1952) and are buried beneath almost 6,000 feet of younger sediments (Stuckey 1965).

Late Cretaceous sediments of Tuscaloosan age which are found further west of the study area are apparently of continental origin. However, the sediments of the Tuscaloosa Formation that underlie the peninsula are oyster-bearing sands, sandstones, limestones, clays, and shales, apparently of marine origin. Microfaunas are rare (Stuckey 1965). These sediments reach a thickness of 1,790 feet in the Esso No. 2 well in easternmost Dare County (Brown 1958).

Younger Late Cretaceous units that overlie the eroded Tuscaloosa Formation vary from the occasionally glauconitic to calcareous, lignite-bearing sands and clays of the Black Creek Formation to the micaceous, calcareous sands, clays, impure limestones, and marls of the Pee Dee Formation. The older Black Creek sediments were probably deposited in very shallow estuarine to marine environments. The overlying, younger Pee Dee sediments reflect an open marine environment, probably less than 300 feet deep. In the easternmost part of Dare County, the Black Creek Formation is 1,300 feet thick and the Pee Dee is 700 feet thick (Stuckey 1965). Late Cretaceous units are buried beneath 2,000 to 3,000 feet of younger sediments.

Cenozoic Era (65 million years B.P. to the present)

Cenozoic formations are widely distributed throughout the Coastal Plain of North Carolina and thicken seaward beyond the present-day coastline. In the central part of the North Carolina coastal region, in the eastern part of the peninsular area, these deposits reach a thickness of 3,033 feet (Cape Hatteras Light Well No. 1) (Stuckey 1965).

Tertiary Period

The Tertiary Period lasted from about 65 to 2.8 million years B.P. and is divided into five time periods call Epochs. The important geologic formations deposited during Tertiary time are discussed below:

Paleocene Epoch. (65 million to 53.5 million years B.P.) Thin strata of Paleocene age probably underlie much of the peninsular area. The Paleocene series is probably less than 25 feet thick in the western part of Washington County but increases to a thickness of almost 200 feet in easternmost Dare County (Cape Hatteras Light Well No. 1 - 163 feet, Swain 1951; Esso No. 2 Well - 189 feet, Brown 1958).

Drill core data to the north and northwest of the peninsula indicate that fine-grained sandstones, shelly glauconitic sandstones, sandy shales, and shelly clays of marine origin occupy a basic structure and reach a thickness of several hundred feet (Stuckey 1965).

P. M. Brown (1958) recognized 65 feet of Paleocene strata in a well drilled for the Nelson Motel in Chocowinity, Beaufort County. He named these strata the Beaufort Formation and designated the Nelson Motel as type locality (Brown 1959).

Eocene Epoch. (∿53.5 million to 37 million years B.P.) Almost 500 feet of fine-grained glauconitic sandstones, sandstones, siliceous limestone, and fossiliferous limestone of Early Eocene age may underlie much of the North Carolina Coastal Plain south of Cape Hatteras. These basal Eocene units are coarsely conglomeratic (Stuckey 1965) and are probably indicative of a basal marine transgression. Beneath the southern portion of the study area these units lie unconformably on eroded older sediments.

The youngest Eocene unit is the Castle Hayne Limestone of Middle Eocene age (46.5-44 million years B.P.) (Jones 1981). This formation is the principal deep aquifer in much of the western part of the study area. It is a fossiliferous grey, usually indurated limestone of marine origin containing abundant shells or usually molds of mollusks; in part it consists of a light colored marl that varies from loose to indurated (Stuckey 1965). In some areas it grades downward into calcareous sand (Heath 1975).

Although the Castle Hayne outcrops to the south of the peninsula in southern Beaufort County, it is deeply buried on the peninsula itself. In western Washington County the Castle Hayne is covered by about 150 feet of younger sediments and soils (Heath 1975); in the vicinity of Cape Hatteras, it is buried under approximately 1,400 feet of younger material.

Oligocene Epoch. (37 million to 24 million years B.P.) Rocks of possible Oligocene age may be present in the Tertiary section beneath the Albemarle - Pamlico peninsula and adjacent areas to the east. These sediments are from 160 to 300 feet thick (Swain 1951). A major problem lies with the placement of the Miocene - Oligocene boundary.

Miocene Epoch. (24 million to 5.2 million years B.P.) A marine transgression occurred in Middle Miocene times (16.5-10.3 million years B.P.) that inundated most of the mid-Atlantic Coastal Plain, with the exception of southeastern North Carolina. The locus of deposition was to the north of the study area in Maryland and northeastern Virginia (Gibson 1962, 1967, 1970). In areas to the south in Beaufort and Pamlico Counties and in the peninsular region, the Middle Miocene depositional environment favored the accumulation of what are now economically significant phosphate ores, occurring as phosphatic sands and stiff phosphatic clays, with some thin layers of dolomitic limestone (Pungo River Formation). The Pungo River Formation probably averages 30 to 40 feet in thickness. At present (1982), the only phosphate mining operations are south of the peninsula (See Mineral and Energy Resources, p. 43) where approximately 30 meters of overburden must be removed to reach the ore body (Redecker and Wright 1978).

Pliocene Epoch. (5.2 million to 2.8 million years B.P.) Either shortly before or during Early Yorktown time, tectonic movements resulted in a southward shift in the locus of marine deposition. Yorktown sea covered parts of southern Virginia and most of northeastern North Carolina (Gibson 1970).

Fossiliferous blue-grey sands, muddy sands, and sandy muds of the Yorktown Formation overlie the eroded Pungo River Formation. The Yorktown Formation outcrops only in a small part of westernmost Washington County. Beneath the rest of the peninsula, the Yorktown sediments are covered by Plio-Pleistocene sands (See Figure 15), and over a wide area in the central part of the peninsula by thick Late Holocene (10,000-4,500 years B.P.) and modern (<4,500 years B.P.) peat deposits.

Isolated surface exposures of the Yorktown Formation are found from the Rappahannock River in Virginia to the Neuse River in North Carolina (Bailey 1973). Within this area of outcrop to the west of the peninsula, thicknesses of the formation vary from only a few feet to 250 feet (Stuckey 1965). However, on the south shore of the Pamlico at the Texasgulf phosphate mine, the Yorktown Formation is less than 50 feet thick. On the peninsula, the Yorktown sediments are probably somewhat thicker. Traditionally this unit has been considered Late Miocene in age, but recent studies indicate that the Yorktown Formation is actually Early to Middle Pliocene (Akers 1972; Baum and Wheeler 1977; Hazel 1971; Snyder et al., in press).

Mansfield (1928) used the name 'Croatan' for the course, sandy, fossiliferous Pliocene sediments that overlie the Yorktown north of the Neuse River. When the volume on Lee Creek that is now in press at the Smithsonian Institution is published, the Croatan Formation will be referred to as Plio-Pleistocene (Clayton Ray to S. Snyder 1979, pers. commun.). South of the Neuse River, Pliocene and Pleistocene deposits are usually assigned to the Duplin Marl (Hazel 1971), the Waccamaw, or to the James City of Dubar and Solliday, 1963 (Hazel 1978). Although Dubar (1959) interpreted the Waccamaw and Croatan Beds of the Carolinas as "pre-Pamlico Pleistocene," others have been more cautious. Richards (1969) concluded that parts of the Waccamaw and Croatan could be Pliocene or perhaps even early Pleistocene. The Waccamaw at Walker's Bluff and near Myrtle Beach, South Carolina is Early Pleistocene rather than Pliocene (Newton et al. 1978).

Quaternary Period

The Quaternary Period began about 2.8 million years ago and is divided into two epochs, the Pleistocene and the Holocene (or Recent). Modern sediments (post-Holocene) are generally considered to be those less than 4,500 years old. On the peninsula, the Pliocene and older deposits are covered with a veneer of non-marine Quaternary sands, silts, and clays that range from 40 feet in thickness in the western part to about 200 feet in the eastern part (Heath 1975). In some areas, Holocene and modern sediments contain organic soils (peat) that may reach 10 feet in thickness in broad shallow depressions and 16 feet in thickness in former stream channels (Ingram and Otte 1982). These surficial deposits are of primary concern in environmental mapping of the peninsular region and, for this reason, the Pleistocene and Holocene to modern evolution of the region will be considered in more detail.

Pleistocene Epoch. (2.8 million years to 15,000 years B.P.) The Pleistocene ice age spanned about one million years. It was a time of complex glacial and interglacial climactic changes and sea level fluctuations. The Pleistocene epoch began about 2.8 million years B.P. and ended approximately 15,000 years B.P. when the most recent major sea level rise began (Milliman and Emerv 1968).

About 100,000 to 75,000 years B.P., when the most recent period of major ice expansion began, the Albemarle-Pamlico peninsula formed the floor of a shallow sea with a coastline in westernmost Washington County. This ancient sea floor is the youngest of several Pleistocene sea floors or terraces and forms a low, nearly level plain. Early in this century it was designated the Pamlico Terrace and was described and mapped by Stephenson (in Clark et al. 1912). Sedimentary deposits that have formed this terrace are from 40 to 60 feet thick in the western part of the peninsular region (Brown et al. 1972).

The waters of the Pamlico sea lapped against what is now called the Suffolk Scarp (Oaks and Coch 1973), a sandy ridge with a toe-altitude of 20 to 30 feet. This seaward-facing scarp that represents the Pamlico shoreline was traced from Virginia to southern South Carolina and named by Flint (1940).

At the time deposits were forming in the Pleistocene, much of North America, north of the Missouri and Ohio Rivers, was covered with glaciers that intermittently advanced and retreated. Thus, from early Pamlico time to about 35,000 years ago, sea level fluctuated both above and below its present level. About 35,000 years B.P. sea level began to decline, and about 15,000 years B.P. reached a stand approximately 400 feet below present mean sea level (Milliman and Emery 1968).

During these sea level oscillations, deltas formed by the ancestral Roanoke and Tar Rivers were extended to the east. Remnants of these deltas are preserved along the north and south sides of the Albemarle-Pamlico peninsula as strips of mineral soils (see Physical Properties Map Series). Buried sandy units beneath Dare and Tyrrell Counties may represent remnants of ancient barrier islands that were formed when sea levels were higher (Heath 1975).

As the sea retreated from the peninsula, channels of the ancestral Roanoke and Tar Rivers and their tributaries migrated eastward, downcutting and forming rather broad, relatively flat-bottomed valleys (Heath 1975). Detailed acoustic profiling of sediments lying beneath the present bottoms of Croatan, Roanoke, and easternmost Albemarle Sounds, has revealed the presence of numerous channels cut into sediments as old as 30,000 years (Riggs and O'Connor 1974). The depth, length, and geometry of these channels seems to suggest that they formed as part of a Late Pleistocene to Early Holocene river-stream system.

As sea level began its most recent long-term rise, following the final Pleistocene glacial period (∿15,000 years B.P.), valleys of the ancestral Tar and Roanoke Rivers and their tributaries have been "drowned", forming the modern estuaries, Pamlico and Albemarle Sounds. Most of the main tributaries are also now estuarine in their lower reaches.

Holocene (or Recent) Epoch. (15,000 years to 4,500 years B.P.) The Holocene sea rise that began about 15,000 years ago has continued to the present. Along the Atlantic coastal margin of the United States, sea level has been rising at the rate of one foot per century since 1890 (Kaye and Stuckey 1973). As long as this sea level rise continues, the Albemarle-Pamlico peninsula will continue to decrease in size. If the present rate of sea level rise should continue uninterrupted for the next 1,000 years, most of the eastern two-thirds of the peninsula will be seafloor; and shallow seas will lap at a shoreline roughly in the vicinity of the Washington-Tyrrell County line.

As sea level began to rise in Early Holocene times following the final Pleistocene glacial period, coastal streams were drowned and large backwater bogs and shallow lakes developed in the broad, shallow, dissected depressions that had formed in earlier times when sea levels were lower. As flooding of low-lying areas continued, swamp forests became established, and the accumulating vegetation eventually became sapric peat (Ingram and Otte 1982).

Peat deposits began to form in these depressions often reaching thicknesses of 8 to 9 feet. In some paleochannels, peat thicknesses of 16 feet have been measured (Ingram and Otte 1982). Thus, it seems very likely that peat accumulations began in the lowest and wettest portions of the Holocene landscape. As these areas progressively filled in, the peat blanket spread across higher ground (Dolman and Buol 1967), forming the broad, slightly dome-shaped "high swamps" called pocosins.

From radiocarbon dates obtained on peat samples from the Great Dismal Swamp north of the peninsula, it is known that peat formation began in that area about 8,900 ± 160 years ago (Oaks 1964). Peat accumulation probably began about the same time on the peninsula (Dolman and Buol 1967).

Modern Times. From about 4,500 years B.P. to the present, the region has passed through a complex series of environmental and vegetational changes, and the warm, humid climate has contributed to the present highly decomposed to decomposed nature of these peats (Ingram and Otte 1982).

Ground Water

Aquifers of the Peninsula

The Quaternary sediments are extremely important to the hydrology of the peninsula. Sand layers in these sediments serve as the primary source of water supply in Dare County and are of importance to shallow well draw throughout the region, particularly in Hyde County (Nelson 1964). Yields of 5 to 10 gallons per minute have been obtained from small diameter wells.

The Yorktown Formation of Pliocene age (see pages 27-28) is an important water supply source. Sand and limestone layers in the Yorktown are the principal source of water supply in Hyde and Tyrrell Counties and are important for Washington County as well. Yields of 5 to 20 gallons per minute are common for wells up to 2 inches in diameter and yields of 75 to 100 gallons per minute can be obtained from wells 6 inches or more in diameter (Nelson 1964).

The Castle Hayne Formation of Middle Eocene age (Jones 1981) (see page 27) is the principal source of water supply in Washington County and the northwestern part of Hyde County (Nelson 1964). Yields of wells drawing from the Castle Hayne (often called the limestone aquifer) depend upon the thickness of the formation at the location of the well. Yields to wells tapping this aquifer are much higher than yields to wells tapping the other aquifers. Wells as small as 10 inches in diameter will yield from several hundred to 1,000 gallons per minute (Wilder et al. 1978).

Waters from the Quaternary sediments and Yorktown Formation tend to be low in dissolved solids, but CO^2 in the water may form a weak solution of carbonic acid. Thus, these waters may have to be treated for excess iron, acidity, or in some cases, hardness caused by solution of shell material. One precaution that must be considered is susceptibility of the shallower aquifers to contamination by agricultural chemicals, fertilizers, industrial wastes, or other noxious materials including leachate from landfills (Wilder et al. 1978).

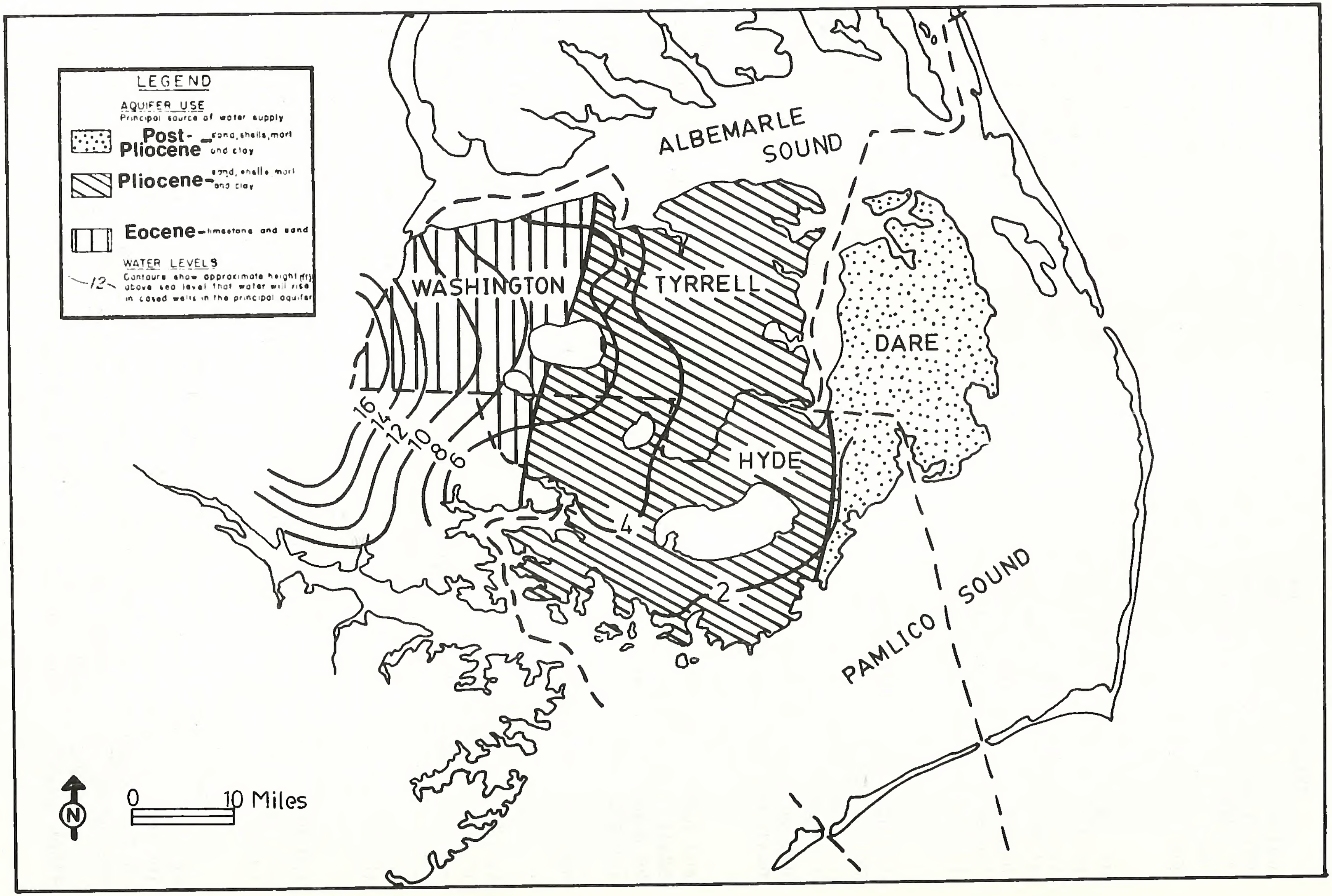
Waters from the Castle Hayne (the limestone aquifer) are generally hard and highly alkaline (dissolved calcium and magnesium), and tend to form silica scale. In the northwestern part of Washington County, iron concentration may be a problem in waters from the limestone aquifer (see Wilder et al. 1978, Table 5), probably because of short aquifer residence time (near recharge areas).

Water-Table Aquifer of the Outer Banks

The water-table (upper) aquifer is the only local source of fresh water supply on the Outer Banks (Wilder et al. 1978). It averages about 15 feet in thickness and is maintained by rainfall. Only in a few places has fresh water moved through the confining beds of silts and clays to deeper aquifers. At Cape Hatteras, fresh water may occur as deep as 120 feet below land surface (Winner 1975). On Roanoke Island, the freshwater lens may be 200 feet thick (Peek et al. 1972).

In order to prevent any rise in the salt water/fresh water interface and reduce drawdown, horizontal wells are used in some areas (e.g. Ocracoke and Salvo campgrounds). Such wells spread withdrawal over a wider area (Winner 1975).

Many areas are unsuited for development of ground water resources because of the extremely shallow nature of the upper aquifer or because salt water inundation is a problem (Winner 1975). Problems with water quality are similar to those within the upper aquifer (Quaternary sediments) on the mainland. On the Outer Banks sewage drainfields and shower outfalls are potential sources of contaminants to ground water supplies. Also, salt water seepage from canals along sound margins can degrade water quality (Winner 1975; Pilkey et al. 1980).



LEGEND
AQUIFER USE
Principal source of water supply
Post-Pliocene – sand, shells, marl and clay
Pliocene – sand, shells, marl and clay
Eocene – limestone and sand
WATER LEVELS
12 Contours show approximate height (ft) above sea level that water will rise in cased wells in the principal aquifer
ALBEMARLE SOUND
WASHINGTON
TYRRELL
DARE
HYDE
PAMLICO SOUND
16
14
12
10
8
6
4
2
0 10 Miles
N

Figure 16. Aquifer Use and Water Levels in Cased Wells (adapted from Nelson 1964).

PHYSICAL PROPERTIES MAP SERIES

Mapping Procedure

The Physical Properties overlay maps and tables that appear on the following pages are designed to provide regional data on the soils, subaqueous sediments, and made lands. Because of the lack of detailed soils data for Dare, Hyde,and parts of Tyrrell County, three sets of maps have been prepared. A generalized Physical Properties map series (at 1:24,000) has been prepared from smaller scale maps (~1:126,720) for the counties that did not have detailed surveys available at time of mapping (1981) (USDA Soil Conservation Service, compiled by the Soil Science Department of N. C. State University in cooperation with the North Carolina Department of Natural and Economic Resources, revised in August 1976) (Table 5). The only detailed soils information that includes parts of Dare and Hyde counties was compiled by First Colony Farms (Table 7). This covers only part of the peninsula and is included as a separate series to avoid confusion with the Soil Conservation Service detailed data. The detailed Physical Properties map series covers all of Washington County, the Outer Banks of Dare and Hyde counties, and parts of Tyrrell County. This map series (1 inch = 2,000 feet) and accompanying tables were prepared from maps and interpretations compiled by the USDA, Soil Conservation Service (the interim Soil Survey for Washington County, 1980, 1 inch = 2,000 feet, the preliminary Soil Survey for Tyrrell County, 1981, 1 inch = 2,000 feet; Soil Survey of the Outer Banks, 1977, 1 inch = 1,000 feet; Soil Maps of Roanoke Island, 1977, 1 inch = 500 feet; additional data from the Technical Guide of the National Cooperative Soil Survey; and Soil Associations of the Coastal Area Management Region, compiled from USDA, Soil Conservation Service maps by the Soils Department of N. C. State University, J. A. Phillips et al.). All numbers used on maps of the Physical Properties series correspond to those used in the above listed surveys and on the First Colony Farms soils map (Tables 5 and 7). A key to the symbols used in Table 5 and all subsequent physical properties tables can be found in Table 6. Additional information on physical properties of these soils is compiled in Table 8. Descriptive information for each land group is based on text material from the previously mentioned USDA, Soil Conservation Service interim, preliminary, or final soil surveys. Subaqueous sediments of Croatan and Roanoke Sounds (Riggs and O'Connor 1974) and Broad Creek on Roanoke Island (Benton 1980) were also mapped.

Mapping Units and Definitions

Soils have been grouped into mapping units based on drainage and textural characteristics. Thicknesses of the organic soils were also factors in determining certain map units. All individual soil types or soil associations (as defined by the USDA, Soil Conservation Service, see Tables 5-8) having similar

Table 5. Soil Groups for Detailed and General Physical Properties Map Series, Albemarle-Pamlico Peninsula and Barrier Islands. (Numbers of soils and soil associations correspond to numbers and names listed for each type of soil survey in Tables 7 and 8. Note: The same soil may have a different number in different surveys, and different soils may have the same number. Please check tables to determine proper name for a given number).

SOIL GROUPS	DETAILED Soil Numbers		GENERAL Soil Association Numbers	
	Detailed (SCS)		Detailed Partial Survey (First Colony Farms)	General (SCS)
	Mainland	Outer Banks & Roanoke Island	Mainland	Mainland
GROUP I Well-drained to somewhat excessively drained mineral soils	(18, 28, 84, 98 - loamy sands) (53 - sandy loams) (86 - sands)	1, 3, 14, 15, 21, 22, 23, 24, 25, 27, 28, 30	--	1 (Some of these soils are poorly drained)
GROUP II Moderately well-drained mineral soils	(3, 35 - sandy loams) (82 - sands)	7, 8, 9, 33	--	--
GROUP III Poorly drained mineral soils	(12, 13, 75, 90, 88 - sandy loams) (9, 54, 56, 94 - silty loams) (41 - loamy sands)	12, 13, 2, 32 34	9	3, 4
GROUP IV Very poorly drained mineral soils	(43, 51, 95 - silty loams) (63 - sandy loams) (21 - loams) (6 - loamy sands)	4, 5, 6, 16, 19 35, 36	11, 13, 15, 16, 17 19, 36	6, 9, 30
GROUP V Very poorly drained mineral soils with organic "veneer"	--	18 (Veneer up to 5" thick)	20, 21, 23, 25 (Veneer from 8" - 16" thick)	--
GROUP VI Very poorly drained shallow organic soils	15, 24, 57, 60, 78, 80, 92 (13" to 51")	20, 26, 37, 38	88, 90, 91, 92, 99, 905 (16" to 51")	7
GROUP VII Very poorly drained deep organic soils (>51")	38, 71	11	94, 96, 97	10, 18
GROUP VIII Very poorly drained organic soils with a mineral "veneer"	39	--	--	--
GROUP IX Artificial land	58, ⊠	10, 17	--	--

Table 6. Key to Symbols Used in Physical Properties Tables

M - moderate, medium

R - rapid

MR - moderately rapid

S - slow

MS - moderately slow

VS - very slow

MH - moderately high

ML - moderately low

VH - very high

H - high

P - ponded

L - low (for Relief, 10' - 24' above mean sea level)

VL - very low (for Relief, 0' - 10' above mean sea level)

N - none (no reasonable possibility of flooding)

O - occasional (flooding less than once every two years)

F - frequent (flooding more often than once every two years)

D - daily flooding

C - common (flooding likely under normal conditions)

Rr - rare (flooding unlikely, but possible under abnormal conditions)

$(\ )^{B}$ - brief duration

$(\ )^{Lo}$ - long duration

$(\ )^{VLo}$ - very long duration

Table 7. Soil Associations for First Colony Farms Partial Detailed Survey of Mainland (Dare, Hyde, Tyrrell, and Washington Counties, modified from Soils Map (1":4,000') of First Colony Farms. *Error on map key from FCF, correction unknown.)

SOIL GROUP	MAPPING NUMBER	CORRESPONDING USDA SOIL CONSERVATION SERVICE NUMBER (SEE TABLE 8)	SOIL SERIES NAME	SOIL DESCRIPTION
III. Poorly drained mineral soils	9	75	Roanoke	Mineral soil with sandy subsoil
IV. Very poorly drained mineral soils	11	-	Rutledge	Mineral soil with sandy or loamy sand subsoil
	13	6	Arapahoe	Mineral soil with coarse loamy subsoil
	15	63	Portsmouth	Mineral soil with fine loamy subsoil
	16	95	Weeksville	Mineral soil with coarse silty subsoil
	17	51	Hyde	Mineral soil with fine silty subsoil
	19	21	Cape Fear	Mineral soil with clayey subsoil
	36	43	Fortescue	Mineral soil with sandy subsoil
V. Very poorly drained mineral soils with organic "veneer" (8"-16" thick)	20	24	Conaby	Organic depth 8"-16", friable organic over sand or loamy sand textured mineral
	21	92	Wasda	Organic depth 8"-16", friable organic over loamy textured mineral
	23	78	Roper	Organic depth 8"-16", friable organic over fine silty textured mineral
	25	57	Pettigrew	Organic depth 8"-16", friable organic over clayey textured mineral
VI. Very poorly drained shallow organic soils (Organic depth 16"-51")	88	80	Scuppernong	Organic depth 16"-51", black organic over silt loam or sand
	90	-	Pamlico	Organic depth 16"-51", friable, black organic over sand or loamy sand textured mineral
	99	60	Ponzer	Organic depth 16"-51", friable, black organic over loamy textured mineral
	91	-	Kilkenny	Organic depth 16"-51", weak colloidal, black, woody organic over loamy textured mineral
	92	15	Belhaven	Organic depth 16"-51", colloidal, reddish-brown, loggy organic over loamy textured mineral
	905	-	Mattamuskeet	Organic depth 16"-51", colloidal, reddish-brown, loggy organic over sand or loamy sand textured mineral
VII. Very poorly drained deep organic soils (Organic depth greater than 51")	96	71	Pungo	Organic depth greater than 51", colloidal, loggy, reddish-brown organic over loamy textured mineral
	97	-	Dare	Organic depth greater than 51", colloidal, loggy, reddish-brown organic over sand or loamy sand textured mineral
	94	-	Frying Pan	Organic depth greater than *16", weak fibrous, rooty, generally reddish-brown, mealy organic, underlying mineral not designated

Table 8. Additional Physical Properties Data for Detailed Soils Maps of Washington County and Portions of Tyrrell County, North Carolina (condensed from USDA, SCS Interim Soils Surveys, 1980 and 1981).

Soil Number	Mapping Unit	Permeability	Available Water Capacity	Subsoil Characteristics (upper/lower)	Shrink-Swell Potential	Relief	Shear Strength	Plasticity	Frequency of Flooding	Surface Runoff	Corrosivity		Erodibility
											Steel	Concrete	
3	Altavista fine sandy loam	M	M	clay loam/sandy clay loam	L	L	L	L	(N-O)^{B}	S	M	M	M
6	Arapahoe loamy sand	MR	M	sandy loam/loamy sand	L	VL	L	L	(O)^{B}	S-P	H	H	M
9	Argent silt loam	S	M	silty clay/silty clay loam	L-M	VL	L	L-M	(F)^{Lo}	VS	H	H	MH
12	Augusta fine sandy loam	M	M	sandy loam/clay loam	L	VL	L	L	(N-C)^{B}	S	M	M	M
13	Barclay fine sandy loam	M	M	clay loam/silt loam	L	VL	L	L	N	S	H	M	-
15	Belhaven muck	S-M	H	clay loam	L	VL	L	L	(F)^{VLo}	VS-P	H	H	-
18	Bojac loamy sand	MR	M	sandy loam/loamy sand	L	L	L	L	(N-C)^{B}	M-S	L	H	MH
21	Cape Fear loam	S	M	clay loam/clay	L-M	VL	L	L-M	(F)^{B}	S-P	H	H	M
24	Conaby muck	MR	H	sand/sandy loam	L	VL	L	L	(O)^{B}	VS-P	H	H	L
28	Conetoe loamy sand	MR	L	sandy loam/loamy sand	L	L	L	L	N-Rr	S	L	H	M
35	Dogue fine sandy loam	MS	M	clay loam/clay and sandy loam	L-M	L	L	L-M	N	MS	H	H	H
38	Dorovan muck	S	H	(mucks may be 108" thick)	L	VL	L	L	(F)^{VLo}	VS-P	H	H	-
39	Dorovan silt loam	S	H	(highly decomposed organic matter from 10-96")	L	VL	L	L	(F)^{VLo}	VS-P	H	H	-
41	Dragston loamy sand	MR	L-M	sandy loam/loamy sand	L	VL	L	L	N	S	L	H	MH
43	Fortescue silt loam	MS	M	organic/sand	L	L	L	L	(O)^{B}	S-M	H	H	H
51	Hyde silt loam	MS	M	silt loam/clay loam and silt loam	L	VL	L	L	(O)^{B}	S-P	H	H	M
53	McQueen fine sandy loam	S	L	clay/silty clay	L	L	L	L	(Rr-O)^{B}	M-S	M	M	VH
54	Muckalee loam	M	M	clay loam/sandy loam to loamy sand	L	VL	L	L	(C)^{B}	M-S	H	M	M
56	Perquimans silt loam	M	M	sandy to silty loam/clay loam, loam	L	VL	L	L	N	S?	H	H	H
57	Pettigrew muck	MR-S	H	mucky clay loam/clay	L-H	VL	L	L-M	(O)^{B}	VS-P	H	H	L-M
58 ☒	Man-made land	-	-	-	-	VL-L	-	-	-	-	-	-	-
60	Ponzer muck	MS-S	H	loam/silt loam	L	VL	L	L	(F)^{Lo}	VS-P	H	H	L
63	Portsmouth sandy loam	L	M	sandy to sandy clay loam/sandy loam	L	VL	L	L	N	S	H	H	M
71	Pungo muck	MS-S	H	clay from 72-84" deep	L-M	VL	L	L	(F)^{VLo}	VS-P	H	H	L
75	Roanoke fine sandy loam	S	M	sandy clay loam to clay/clay loam to sandy loam	L-M	VL	L	L-M	(F)^{B}	S	H	H	-
78	Roper muck	MR-MS	H	silt loam	L	VL	L	L	(O)^{B}	VS-P	H	H	L
80	Scuppernong muck	S-MS	H	silt loam/sand	L	VL	L	L	(C)^{Lo}	VS-P	H	H	L
82	Seabrook fine sand	R	L	(sands may be 60" thick)	L	VL	L	L	N	M-S	L	M	L
84	State loamy sand	MR-M	M	sandy loam to clay loam/sandy loam	L	L	L	L	(N-O)^{B}	S	L	H	M
86	Tarboro sand	R	L	(sands may be 100" thick)	L	L	L	L	N-Rr	S	L	M	M
88	Tomotley fine sandy loam	M-MS	M	sandy loam/sandy clay loam	L	VL	L	L	Rr	S	H	H	ML
90	Wahee fine sandy loam	S	M	sandy clay loam to clay/sandy clay loam	M	VL	L	L-M	N	S	H	H	M
92	Wasda muck	MR-MS	H	clay loam/sandy loam	L	VL	L	L	(F)^{Lo}	VS-P	H	H	L
94	Wehadkee silt loam	M	M	clay loam to sandy clay loam/sandy loam, sand, to loamy sand	L	VL	L	L	(C)^{B}	S-P	H	M	M
95	Weeksville silt loam	M	M	silt loam/sandy loam	L	VL	L	L	N	S	H	M	-
98	Wickham loamy sand	MR-M	M	sandy clay loam to sandy loam/loamy sand	L	L	L	L	N-Rr	S	M	H	M-H

characteristics are delineated by the same black-and white patterns (see map legends). Each detailed map may have up to eight mapping units (of nine possible), and the general maps may have as many as five (for comparison, see Table 5). Borrow pits and quarries are also included on the detailed maps, as are sanitary landfills, other man-made lands, and sewage treatment facilities.

The nine detailed Physical Properties mapping units are:

Group I Lands

The soils of Group I Lands are primarily sands, loamy sands or sandy loams (mineral soils) that are either excessively drained, somewhat excessively drained, or well-drained. On the mainland, such soils usually occur in small areas (<50 acres) on low to high broad ridges (0-3 percent slope) along the Albemarle and Pamlico Sounds and adjacent upland stream terraces. These soils (and the soils of Groups II, III, and IV Lands) represent remnants of deltas formed by the Roanoke and Tar Rivers during higher stands of sea level over the last one million years (Heath 1975).

Most of these soils have a low organic content in the surface layers, are moderately permeable, have low shrink-swell potential, and a seasonal high water table from 1 to 6 feet beneath the surface. On the mainland, most of these soils are farmed; some are in woodland and pasture. They have good potential for most engineering, urban, and recreational uses but are not suitable for solid or liquid waste disposal sites.

Lands classified as Group I form a large part of the modern barrier island system including the beaches and dunes, as well as flats, sandy ridges, and side slopes along the sound side of the islands.

Group II Lands

Lands in this group have soils that are primarily moderately well-drained sandy loams and sands (mineral soils). On the peninsula, these soils usually occur in small areas (40 to <100 acres) on broad to low ridges and flats (0-3 percent slope), between dissecting streams along the Pamlico River and Albemarle Sound, the Roanoke River, and adjacent stream terrace divides. On the barrier islands, these lands form the broad, nearly level to gently sloping flats that lie behind foredunes. In places where the islands are narrow such soils may extend to the sound.

Most of these soils have low organic content in the surface layers and are slightly to moderately permeable. Although they have low shrink-swell potential, their suitability for most urban uses is only fair to poor because of wetness and a seasonally high water table.

On the peninsula most Group II Lands are cultivated; some are in woodland and pasture. On the barrier islands most of these lands are vegetated with saltmeadow cordgrass, other grasses, shrubs, or, in more protected areas, by live oak, loblolly pine, and yaupon (maritime forest).

Group III Lands

Lands classed as Group III have poorly drained mineral soils, usually sandy loams, silty loams, or loamy sands. Mapped areas of individual soil types range from 4-40 acres up to 500 acres. On the mainland and on Roanoke Island, these lands form either broad level 'blackland' flats or depressions on the upland areas along the Albemarle Sound and on low stream terraces. On the barrier islands,Group III Lands form nearly level to slightly depressional flats that extend inland from the frontal dunes, or along the edges of freshwater marshes.

Most of the soils of Group III Lands have moderate to low organic content in the surface layers. They are slightly to very permeable with a low to moderate shrink-swell potential. The seasonal high water table ranges from the surface to 1 or 2 feet below the surface. The suitability of these lands for most urban and recreational uses is poor because of wetness. Possibilities for engineering uses are generally poor, although extensive drainage and site modification can improve the potential for dwellings with septic tank absorption fields.

About half of these lands on the mainland and Roanoke Island are cultivated. The rest are in woodlands or pasture. On the Outer Banks, Group III Lands are usually vegetated with dense stands of saltmeadow cordgrasses; if forested, these lands have stands of such water-tolerant species as loblolly pine, water oak, and sweet gum.

Group IV Lands

Lands included in this group have very poorly drained mineral soils; loams (usually sandy or silty) and loamy sands on the mainland, and loamy sandy or sandy marsh soils on the sound side of the Outer Banks.

On the mainland, Group IV Lands occur on broad flats in the 'blacklands' and in slight depressions along the Roanoke River and Albemarle Sound terrace landscapes. On Roanoke Island, these lands may occupy floodplains of streams. Mapped areas of individual soil types range from 20 to 2,000 acres.

Most of the soils of Group IV Lands have some organic matter (3-20 percent) in the surface layers and are slightly to moderately permeable. Their shrink-swell potential is low-to-moderate. Their potential for urban, recreational, and engineering uses is poor to very poor because of wetness. The seasonal high water table is at or within 1 foot of the surface. Some of the Group IV Lands on the mainland and on Roanoke Island are flooded frequently for brief periods. On the Outer Banks, they are either flooded daily by tides or periodically by storm tides.

On the mainland most of these lands are farmed; some are in pasture or woodlands. Wetness is the main limitation for most crops. On the Outer Banks, most of these very poorly drained, sandy or loamy sandy soils are covered with dense stands of saltmeadow cordgrass. Some are dominated by black needlerush or are nonvegetated.

Group V Lands

Lands included in this group have very poorly drained mineral soils with a thin 'veneer' of organic material. If the USDA Soil Conservation Service classifications are used, lands classed as Group V have only one soil type. These lands are irregularly flooded salt marshes that cover fairly extensive areas on the back side of the barrier islands. The substrates of these marshes are sands or loamy sands with varying amounts of shell material. The surface layer is usually a dense mat of roots.

These lands lie about one to 1 1/2 feet above mean sea level and are flooded at least monthly. These marshes are usually vegetated heavily with black needlerush, some scattered patches of saltmeadow cordgrasses, sea oxeye, and other such salt marsh vegetation. Poor drainage and intermittent flooding make these lands unsuitable for most urban, engineering, or recreational uses.

For the purposes of this project, several types of lands that would be included with Group V by First Colony Farms were classed as Group VI in the atlas (see Table 5 for clarification, SCS soil types 24, 57, 78, 92).

Group VI Lands

Lands classed as Group VI have very poorly drained, shallow organic soils, usually more than 12 inches but less than 51 inches thick; subsurface materials are usually mucky, silty, sandy, or clayey loams. On the mainland, these soils have formed on broad flats in the "blacklands." Mapped areas that have soils of a single type may be as small as 30 acres or as large as 2,000. On the Outer Banks, Group VI Lands occur in depressional areas between forested dunes (e.g., Buxton Woods) or as near sea-level marshes on the sound side. Most of these lands have soils with moderate to slow permeability. Surface runoff is slow to ponded. Organics comprise about 85 percent of the surface layers of these lands.

Although Group VI Lands have poor potential for most urban and engineering uses, on the mainland they are suitable for agriculture if well-drained and carefully managed. About half of the Group VI Lands in the 'blacklands' are farmed; the rest are in woodlands or pasture. Some large areas have been burned and support only briers and shrubs. On the Outer Banks, the dominant vegetation is black needlerush (marshes) or saw grass (between the dunes).

Group VII Lands

The soils of this group are very poorly drained deep organics that exceed 51 inches in total thickness. On the mainland, Group VII Lands occur on the floodplains of the major streams and rivers and on low-lying areas adjacent to the Albemarle and northern Croatan Sounds, as well as on broad flats in the 'blacklands'. Individual areas of a single soil type vary in size from 25 to 6,000 acres.

In the vicinity of Nags Head Woods on the Outer Banks, and particularly on Roanoke Island, such soils occur in extensive low-lying (3 feet above mean sea level) marshes that are flushed with brackish and fresh water during storms and high winds. These soils are highly decomposed (sapric) except for a dense mat of living and partially decayed roots in the upper 16 inches.

Permeability of Group VII soils is slow to moderate. Surface runoff is very slow to ponded. These soils are continuously wet. Flooding is common for brief to very long periods of time. Most of the Group VII lands on the mainland are wooded; dominant species are bald cypress, swamp tupelo, water tupelo, and Atlantic white cedar. The combination of landscape position, continual wetness, and the organic soils makes Group VII Lands unsuitable for purposes other than wildlife habitat. Several large areas of these deep organics have been burned repeatedly, particularly northeast of the bombing range in Dare County.

On Roanoke Island and near Nags Head Woods, these lands are usually vegetated with dense stands of black needlerush. The slightly higher fringing areas support other wetland species such as eastern baccharis, giant and saltmeadow cordgrasses, cattails, as well as clumps of stunted pines and live oaks.

Group VIII Lands

Lands classed in this group have only one soil type, the Dorovan silt loam. This soil is a very poorly drained, deep organic with a silt loam 'veneer' up to 10 inches thick. This soil occurs only on the mainland, along floodplains of small streams and their tributaries. Mapped areas are very narrow and elongate, varying from 5 to 50 acres in size.

Flooding is common for brief to very long periods. Lands of Group VIII have a low potential for urban, recreational, or engineering use. The soils are usually saturated. Organic content of this soil type is 75 percent; occurrence of logs and other coarse woody material in the soil is common. Most of the Group VIII Lands are wooded. Among the dominant native species are ash, bald cypress, and swamp tupelo. Although the potential is good for certain trees, the saturated organic soils and flooding limit woodland management and use.

Group IX Lands

All lands classed as Group IX are man-made. These occur on both the Outer Banks and the mainland, and include spoil piles such as those that result from maintenance dredging of the Intracoastal Waterway; made lands, usually materials deposited between canals during construction for use as building sites; sanitary landfills; and all other man-made lands.

Most of the lands classed as Group IX are very sandy or shelly; water moves through such soils rapidly. These soils are usually droughty and have poor filtering capacity for septic tank effluent. The potential for groundwater contamination is very high. Many of these areas were not seeded or shaped after dredging and, as a result, are barren or only sparsely vegetated. Coastal bermudagrass can be used to stabilize such areas; they often revegetate naturally with smooth cordgrass or largeleaf pennywort.

Summary

Data in this section was adapted from the narratives and soil interpretation sheets of the previously mentioned Soil Conservation Service surveys and from supplementary interpretation sheets. This material is intended to convey a summary description of the characteristics that soils comprising a particular group have in common. For more detailed information on any soil type or for site-specific information, the reader is advised to consult with the district conservationist or county soil technician. Addresses and telephone numbers for the four counties are:

Soil Conservation Technician, Hyde County
U.S.D.A., S.C.S.
Post Office Box 264
Swan Quarter, N.C. 27885
Phone: 919/926-4361

District Conservationist, Dare County
U.S.D.A., S.C.S.
Post Office Box 1047
Manteo, N. C. 27954
Phone: 919/473-2529

Soil Conservation Technician, Tyrrell County
U.S.D.A., S.C.S.
Post Office Box 162
Columbia, N. C. 27925
Phone: 919/796-3891

District Conservationist, Washington County
U.S.D.A., S.C.S.
Post Office Box 1007
Plymouth, N. C. 27862
Phone: 919/796-3891

MINERAL AND ENERGY RESOURCES MAP

Mining and Exploration in the Coastal Region

No deposits of oil, gas, or coal have been discovered in the North Carolina coastal region (Stuckey 1965). The first exploratory oil well in North Carolina was drilled in 1925, near Havelock, in Craven County. By 1977, 120 wells had been drilled in 23 counties, primarily in the coastal zone but as far inland as Lee County (Coffey 1977). All holes were dry.

Mineral Resources

Some lease prospecting and exploration for ilmenite-bearing sands in the North Carolina coastal region took place in the 1950's. Ilmenite is one of the chief ore minerals of titanium. It occurs as an accessory mineral in some metamorphic and igneous rocks. Upon weathering, these rocks yield the stream and beach placer deposits that furnish most commercial titanium. Ferrocarbon titanium is often alloyed with steel. Titanium oxide is used as a pigment in paints, linoleum, white inks, colored glass, pottery glazes, and for dying leather, and in alloys as a coating for welding-rods, and in electrodes for arc lamps (Stuckey 1965). The ilmenite sands of North Carolina's coastal zone occur in and around Albemarle Sound; in some areas southwest of the study area, in Beaufort and Onslow Counties; and also north of the peninsula, in Gates County. No mining for ilmenite has been done, and attempts at exploration had ceased by 1960 (Stuckey 1965).

Sand for concrete and for other similar engineering and architectural uses is mined at numerous small sites. Also, some shell is quarried along the Outer Banks. Although agricultural marl and limestone quarries were operated extensively in many areas of the North Carolina Coastal Plain in the latter part of the 19th century and during World War I, most of these operations have long been abandoned. Since World War II, shell limestone and marl have been produced at three quarries; one near Castle Hayne in New Hanover County, one at Belgrade in Onslow County, and one at New Bern in Craven County. There are no operations on the peninsula or the adjacent Outer Banks. Although extensive limestone deposits underlie much of the Coastal Plain, the thickness of overburden makes quarrying economically unfeasible in many areas (Stuckey 1965, Mideast RC & D Council 1975).

The only economically valuable mineral resource in the North Carolina coastal region is phosphate, occurring as carbonate fluorapatite in the Pungo River Formation of Middle Miocene age (see Figure 15). This formation underlies much of the Outer Coastal Plain north of the Neuse River. Phosphate is mined in central Beaufort County, just southwest of the Albemarle-Pamlico peninsula, on the south shore of the Pamlico River near the town of Aurora. The Lee Creek mine, in operation since 1965, is owned by Texasgulf, Inc. Agricultural phosphate and phosphoric acid are the major products. Gypsum (calcium sulfate) is a chemical by-product (Mid East RC & D Council 1975). North Carolina produces about 15 percent of the nation's agricultural phosphates and about 8 percent of the world's supply (Stan Riggs, 1982, pers. commun.). Phosphate is not mined on the peninsula.

Phosphate is not presently mined on the peninsula; however, phosphate bearing sediments of the Pungo River formation are known to underlie the study area extensively (Miller 1982). Present phosphate mining techniques utilized in Beaufort County south of the study area utilize drag lines and dredges. The depth to the phosphate beds which underlie the peninsula make them impractical for mining using these methods. It should be noted, however, that progress is being made in developing technologies which may be applied to such deposits. When perfected, the phosphate sediment may be brought to the surface without the necessity of removing the overburden. It seems likely that new techniques will make this possible within the next decade. At that time the deeper phosphates underlying the peninsula should be re-evaluated as a potential major resource.

Energy Resource - Fuel-Grade Peat

Fuel-grade peat is defined by the U. S. Department of Energy as a soil having at least 75 percent organic matter and less than 25 percent ash (mineral matter) on a dry-weight basis (L. J. Otte 1982, pers. commun.).

The only potentially valuable energy resource in the coastal region is a generally fine-grained, highly decomposed black peat with an ash content usually less than 10 percent (Otte and Ingram 1980, Ingram and Otte 1982). There are extensive peat deposits in the North Carolina coastal region. The largest deposits are found in the Albemarle-Pamlico peninsula. Calculations by Ingram and Otte (1982) indicate that there are about 278 million tons (on a dry weight basis) of peat on the peninsula.

The peats are generally sapric, moderately to highly decomposed, and contain considerable wood. Ash content is generally low (6-10 percent average). Two main types of peat are present: 1) an upper brownish-black, fine-grained, highly decomposed sapric peat and 2) a lower, reddish-brown, decomposed fibrous sapric peat. Stumps and logs are most abundant in the thicker peat deposits, although they also occur quite frequently throughout, except in the basal few feet of the deep channels (Ingram and Otte 1982).

Peat deposits are associated primarily with the Alligator River drainage system. Thick peat occurs along both shores. Peat-filled tributaries extend eastward into Dare County and southward into Hyde County. Tributaries also extend westward into Tyrrell County, where the peats of the Southwest Fork of the river are very extensive, spreading westward and south in the vicinity of Lake Phelps.

The peats of the peninsula yield approximately 10,000 Btu's per pound (moisture free) and could provide almost 6 quadrillion Btu's of energy value if mined completely and used efficiently. This could meet the State's thermal needs for almost four years at 1980 consumption levels (calculated from Ingram and Otte 1982, Harwood and McMullan 1981). Although some workers feel that peat is an economically competitive fuel and that its removal would transform land of "limited economic productivity" into land productive for "energy, agriculture, and wildlife" (Harwood and McMullan 1981), others feel that many questions need to be answered before large scale peat mining is permitted (Cooper 1981).

As with all non-renewable resources, when the peat is used up the problem of future energy sources will remain unsolved, leaving the land irrevocably changed. If the subsoils beneath were to be farmed, increased nutrient loads could encourage red-sore disease on game fish as well as other problems and cause severe declines in fish populations that are already severely stressed (Taylor 1981, from Pete Kornegay).

Mapping Procedure and Sources

The Mineral and Energy Resources Map was compiled at a scale of 1:126,720. The locations of sand and shell pits were not mapped on this scale because of their extremely small size; but when exact locations were known, these pits were designated on the corresponding maps of the Physical Properties Map Series (scale 1:24,000). The areal extent and thicknesses of the peats have been mapped according to Ingram and Otte (1982, Plate 1). Locations of permitted (and pending) peat mine operations of the peninsula are included on the Land Use and Land Cover Map Series (see page 70). Areal extents of the organic soils, as mapped by the USDA Soil Conservation Service (see Physical Properties Map Series) do not always agree with the peat outlines of Ingram and Otte (1982) (Mineral and Energy Resources Map). This is because the terms "organic soils" and "histosols" include soils that may be as high as 70-80 percent ash (dry weight) rather than just organic soils having less than 25 percent ash.

Exploratory oil and gas wells drilled from 1925 to 1976 have been mapped from data compiled by Coffey (1977). Additional data on these wells are found in Appendix B.

Information on the buried phosphate-bearing unit (Pungo River Formation) is not mapped on the Mineral and Energy Resources Map because drill holes are too few to permit contouring of the paleosurface (top of the phosphate unit), except in a very generalized way (Figure 17).

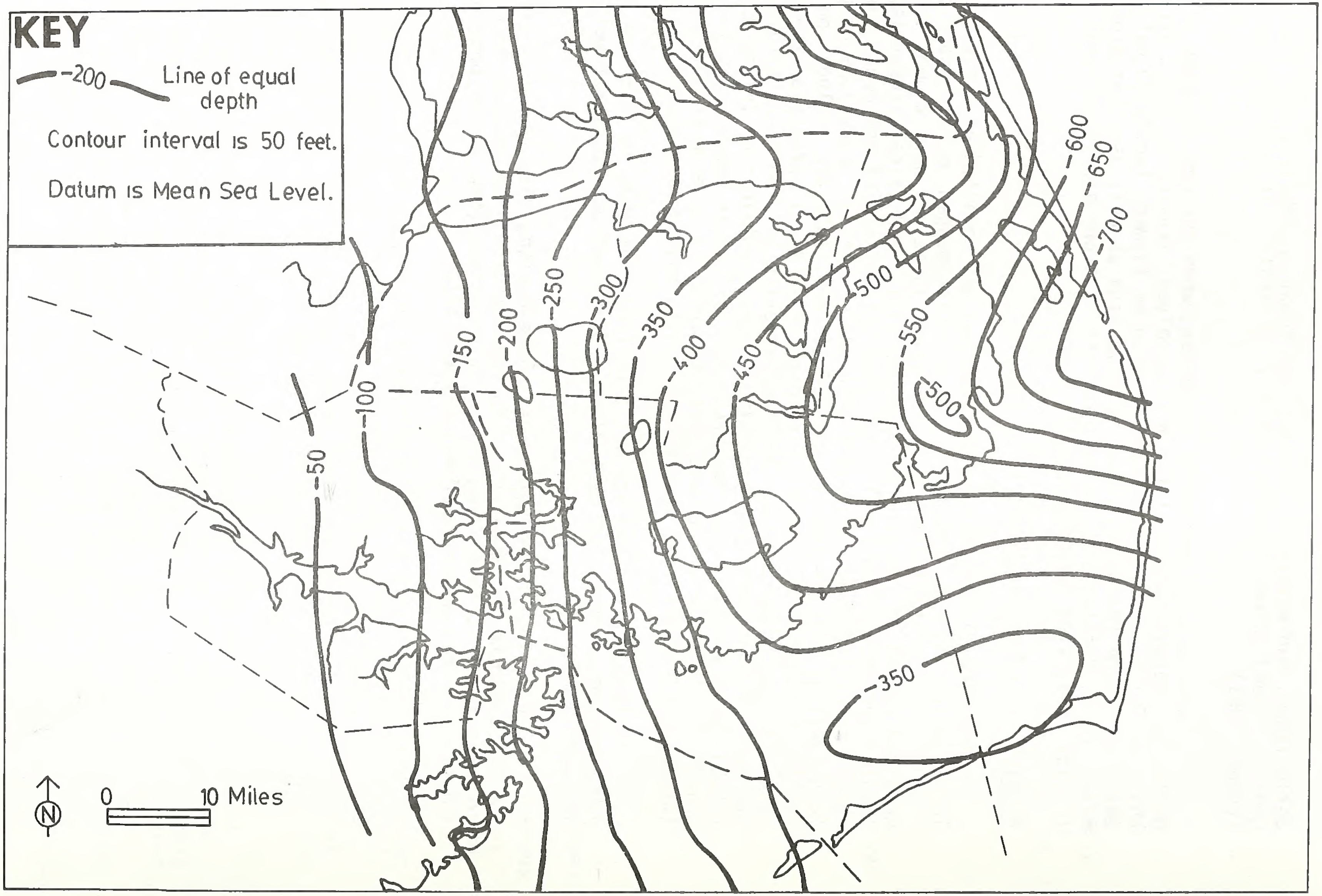


Figure 17. Depth to the Top of the Pungo River Formation (from Heath 1975, after Brown et al. 1972).

Historical Background

The Albemarle-Pamlico peninsula is a region of low-lying, largely poorly-drained lands that currently (1982) supports less than one percent of the state's population. These low population densities reflect the inherent limitations for development of much of the land. Deep, wet organic soils have historically been difficult to clear, farm, or develop by conventional means. Traditionally, farm lands were restricted to northern Washington County, northwestern Tyrrell County, and southern Hyde County, largely around Lake Mattamuskeet. Clearing and ditching of large tracts of land did not become feasible until the introduction of heavy equipment technology and corporate farming methods in the early 1970's.

Early European Settlements

The peninsular region was first explored in 1584 by the Englishmen, Philip Amadas and Arthur Barlowe, under a patent issued by Queen Elizabeth to Sir Walter Raleigh (Lefler 1965). It was densely wooded area, with vast, almost impenetrable virgin forests--"woodes, not such as you finde in Bohemia . . . barren and fruitless, but the highest and reddest Cedars in the world . . . Pynes, Cypres, Sassaphras, . . . and many other excellent smell and qualitie" (from description of Roanoke Island by Arthur Barlowe in 1584; Lefler 1965).

A colony was established in 1585 on the northern tip of Roanoke Island. This "Cittie of Raleigh" became the first permanent English colony on the North American continent. In 1590, when John White returned to the island of Roanoke, the colonists had disappeared (Sharpe 1966). The actual fate of this "Lost Colony" has never been resolved.

For about 100 years following the disappearance of Raleigh's colony, early settlers made no attempts to settle the more remote and inaccessible peninsula. About 1700, settlers began to move into higher, better drained areas fringing the sounds and larger rivers. The earliest business-industrial venture was a water-driven sawmill that went into operation on Kendricks Creek near the present town of Roper in Washington County in 1702 (Sharpe 1966) (Figure 18).

Early colonists encountered several small, widely scattered settlements built by Indians of Algonquin stock. Many of these Indian villages were located within areas that subsequently became farmlands of the colonists. These lands were better drained, more productive, and more accessible (Figure 18).

Early Development and Farming

Alteration of natural drainage patterns began in the 1780's, when an attempt was made to drain Lake Phelps so farms could be started on the rich

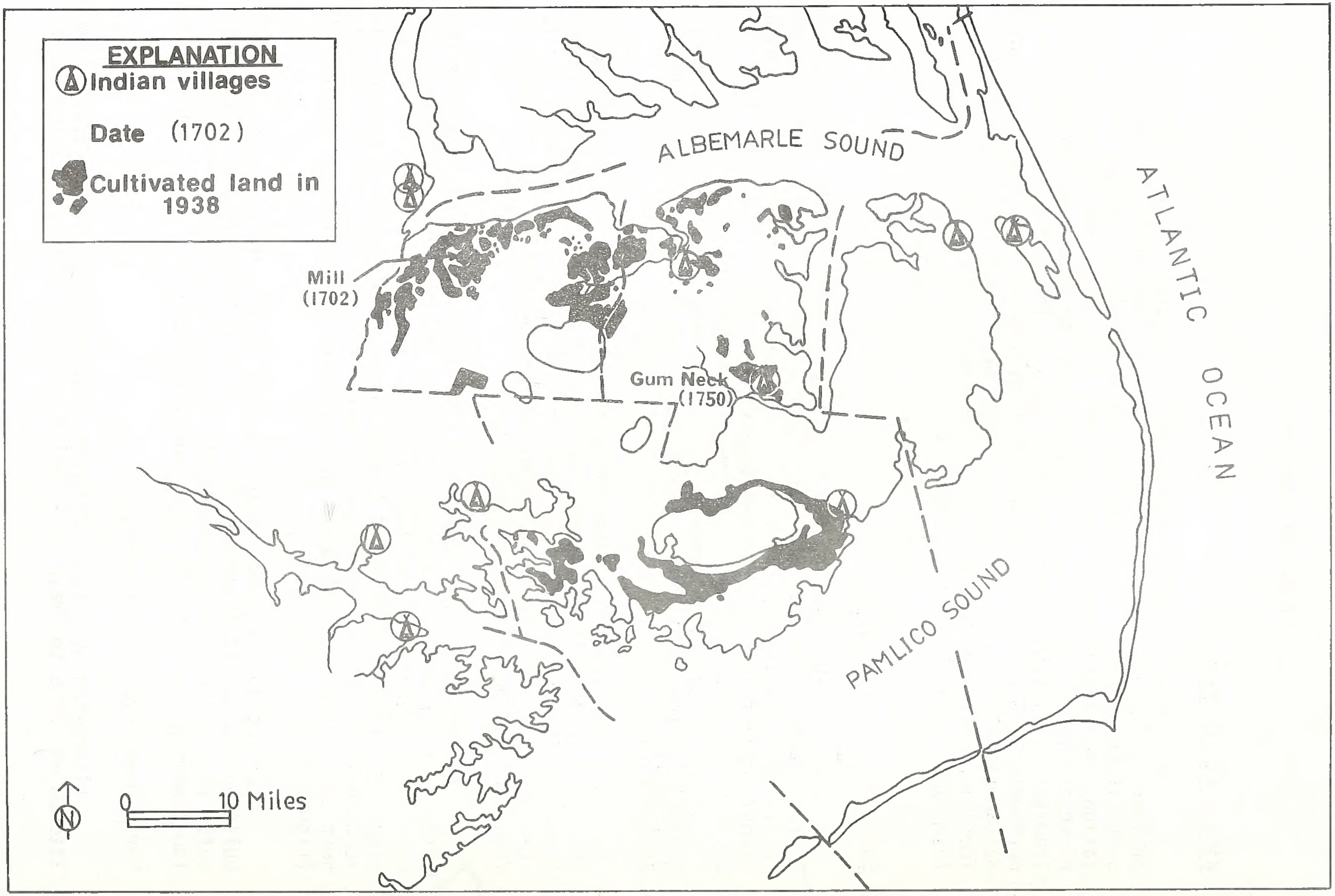


Figure 18. Indian Villages at Time of First European Colonies and Regions of Historic Farm Lands (adapted from Heath 1975).

bottomlands. The Lake Phelps canal was finished in 1787, and the level of the lake was lowered enough to permit farming on 10,000 acres around its margin. Rich harvests of corn, wheat, and rice built its reputation as one of the finest Pre-Civil War plantation areas in the country (Sharpe 1966).

About 1830, attempts were initiated to encourage development of the Albemarle-Pamlico area. Numerous canals were dredged to connect the lakes with the rivers. By the time of the Civil War, nearly 70,000 acres in the vicinity of Pungo Lake and New Lake had been drained. Large canals had also been completed from Lake Mattamuskeet to Pamlico Sound and northward to the Alligator River (Vaughn 1884). However, these drainage efforts failed to attract many settlers, probably because of the widespread belief that malaria was caused by the 'bad air' of swampy regions (Heath 1975).

Another attempt to settle the swamps was sponsored in the early 1900's by the Roper Company (Lumber) and the Norfolk and Southern Land Company. Tracts of land were offered for sale in the region of Lake Phelps (Heath 1975). Evidently, there were few takers and this second major effort to settle the interior also failed.

Attempts to drain Lake Mattamuskeet were also begun in the early 1900's. For varying lengths of time from 1913 to 1933, three different private companies were involved in the drainage and farming of Lake Mattamuskeet. No more than 12,000 acres were ever under cultivation at any one time on what had been the lake bottom (Sharpe 1966). Pump breakdowns and agricultural pests began to cause problems too large to handle. Lake Mattamuskeet reverted to state control in February 1933. In 1934 the Federal Government purchased the lake, and Mattamuskeet National Wildlife Refuge was created (Heath 1975).

Recent Changes in Agricultural Land Use

The Albemarle-Pamlico peninsula has a land area of 1,634 square miles. In 1938-1939, only 156 square miles had been cleared and cultivated. By 1973, 420 square miles were under cultivation (Heath 1975). By the early 1970's the region had experienced a decline in the number of farms. Farms had become larger in size, more mechanized, and agricultural employment had dropped (Coastal Zone Resources Corp. 1976).

By 1974, large corporate farms had purchased three largely undeveloped land tracts that totaled approximately 648 square miles (414,500 acres). The ultimate goal of these large land acquisitions was clearing and draining for cropland, pastureland, and livestock production (Daniel 1978). A projection for land under cultivation by 1980, based on preliminary plans of the larger corporate farms, was 828 square miles (529,920 acres) (Heath 1975), an increase of 408 square miles over the 1973 figures for cultivated area on the peninsula. The actual total acreage cleared and under cultivation at present is not known.

The major crops produced by the large corporate farms are soybeans, winter wheat, corn, and sorghum. The corn and soybeans are used as livestock feed. Wheat, soybeans, and surplus corn are sold at market (Coastal Zone Resources Corp. 1976). Smaller farms also produce these crops, as well as cucumbers and other truck crops (Hyde County Land Use Plan 1976). On much of the peninsula, production of some crops, including soybeans and corn, has increased dramatically since 1971 (Tyrrell County Land Use Plan 1980).

Lumbering on the Peninsula

Much of the land now owned by the large corporate farms has traditionally been utilized as timberland. Much of the region has been cleared of sawlog timber, particularly in the last 50 years. Roper Lumbering Company had a large operation in the 1920's and 1930's. By 1959 Westvaco had acquired most of the land previously logged by Roper Lumber Company in Washington County, as well as many thousands of acres in Dare and Tyrrell Counties, with some in Hyde. Westvaco's total land holdings exceeded 300,000 acres (Coastal Zone Resources Corp. 1976).

During Westvaco's ownership of land from the 1950's to the 1970's, 400 miles of roads and 1,000 miles of ditches were completed (Tilley 1973). These changes in natural drainage patterns were deemed necessary to increase yields in sawlog and other timber. Other present-day land owners, including Weyerhaeuser, Union Camp, and Georgia Pacific in Washington County, also have added new canals and roads, and will continue to manage large tracts of land as forestlands. The extent of ditching that has occurred in recent years in any one area can be evaluated by consulting the appropriate map overlay in the Drainage and Bathymetry series. However, actual figures on miles of new ditches since 1974 have not been calculated.

Environmental Impact of Changing Land Use

Increased drainage operations for agricultural, mining, or forest improvement purposes should be monitored in such a way that damage to the rivers and estuaries is minimized. Increased runoff can clog streams and rivers with sediment and increase water pollution through the addition of pesticides and fertilizers (Washington County Land Use Plan 1980). Increasing fresh water runoff into brackish estuarine areas can upset the chemical balance of aquatic nursery areas and reduce yields of marketable species.

Mapping Procedure

The Land Use and Land Cover overlay maps and tables are designed to provide regional information on land use in the Albemarle-Pamlico peninsula. Herein, land use refers to man's activities on land which are directly related to the land. Land cover refers to the vegetational and artificial coverings on the land surface.

Maps of this series were compiled at a scale of 1:24,000 using USGS 7 1/2 minute topographic quadrangles as a base. USGS orthophotoquads (1:24,000), topographic maps, and a regional land use and land cover map (Daniel 1978) were used to prepare preliminary land use and land cover maps at 1:24,000 scale. These data were updated using 1980-1981 panchromatic aerial transparencies*, a natural areas inventory (McDonald and Ash 1981), and the North Carolina Forestry Pre-Attack maps.

The final Land Use and Land Cover maps prepared for this report were drafted in a linear style without patterns or color, for simplicity and clarity. Artificial drainage systems were incorporated into a separate map series (Drainage and Bathymetry) in order to avoid confusion.

Explanation: Land Use and Land Cover Mapping Classification System

Source and Modifications

The Land Use and Land Cover classification system adopted for this map series was developed by Anderson *et al*. (1976) for the U. S. Geological Survey. This classification system was designed so that the mapping units could be expanded or condensed in order to conform to particular user needs. Its advantages include applicability over extensive areas, suitability for use with aerial photographs, limited requirements for ground reconnaissance, potential for high level of interpretation accuracy, and a high degree of compatibility with other systems in use by various government agencies.

Minor modifications were made to the USGS classification system to conform to particular management requirements. On the peninsula, extensive tracts of various types of Wetland necessitated that such lands be mapped at different classification levels when sufficient data exist (see following section). On the Outer Banks, the classification system was expanded in order to pinpoint emergency services, transportation facilities, utilities, and various types of residential areas. These mapping units are important because of the vulnerability of the barrier islands to storms and the problems that can arise from development of environmentally fragile areas.

Land Cover

Biotic land cover units that have been mapped on the Land Use and Land Cover Map Series indicate the predominant vegetation types present in a particular area. In some instances, the biotic land cover units mapped represent areas with intermixtures of different vegetation types too small to be designated as separate units. For the most part these areas occur where intricate soil patterns or irregular topography exist. Plant nomenclature in the text follows Radford et al. (1968) whenever possible. However, some common names are from a handout (undated) on "Major Vegetative Communities of the North Carolina Coastal Plain" used in a field botany course at East Carolina University (references listed as Cooper, A. W. -unpublished notes; Wells, B. W., 1937, Natural Gardens of North Carolina, UNC Press) and from Seacoast Plants of the Carolinas (Graetz 1973). These common names may differ slightly from those used in other publications.

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*The source of 1980-1981 aerial photographs was Abrams Aerial Service. Survey flights were flown at an altitude of 12,000 feet using standard aerial photography techniques.

Mapping Levels

In the system described in the preceding section, there are four classification levels utilized. A multilevel system is necessary because different sensors will provide data at differing resolutions that are dependent upon both altitude and scale. In general, the following relationships apply, if a 6-inch focal length camera is used in obtaining the imagery (Anderson et al. 1976): Level I. Landsat (satellite) type of data; Level II. High-altitude data at 40,000 feet (12,400 m) or higher (scale smaller than 1:80,000); Level III. Medium-altitude data taken between 10,000 and 40,000 feet (3,100 to 12,400 m) (scale from 1:20,000 to 1:80,000; Level IV. Low-altitude data taken below 10,000 feet (3,100 m) (scale larger than 1:20,000).

Level I is very small scale and generalized, and no Level I divisions are utilized on the atlas project maps. However, an explanation of the types of data included at Level I is included within the following discussion because all subsequent levels which are mapped (II, III, and IV) are breakdowns of Level I. A Level I division is defined by a one-digit arabic numeral (e.g., 6. Wetland).

Level II data is less generalized than Level I, and numerous Level II categories are utilized in the mapping project. Level II categories are defined by a two-digit arabic numeral (e.g., 61. Forested Wetland).

Level III data is more detailed than Level II; and some, but not all, Level II categories have been subdivided to Level III. Level III mapping units are defined by a three-digit arabic numeral (e.g., 611. Swamp Forest), except under Grass and/or Shrub Brushlands (33) of the Outer Banks. Here small letters are used because of space limitations (see page 59-61).

Level IV mapping units give the most specific type of information mapped in the atlas. However, only a few Level III mapping units are divided to Level IV. These Level IV units are defined by a four-digit arabic numeral (e.g., 6112. Atlantic White Cedar Swamp Forest).

Mapping Units and Definitions

1. Urban or Built-up Land

Urban or Built-up Land includes cities, towns, villages, strip developments along highways, transportation, power and communications facilities, as well as areas occupied by shopping centers, mills, industrial and commercial complexes. This division and its mapping units take precedence over all others when the criteria for more than one category are met. Seven categories of Urban and Built-up Land mapped at Level II, and some of these are subdivided to Level III:

11. Residential. In many areas in North Carolina, residential land uses range from high density urban cores with multiple unit housing to low density, peripheral areas with single-family homes on large lots. However, there are no large urban areas on either the peninsula or adjacent Outer Banks. The largest town is Plymouth, in Washington County, with a population of 4,571 (1980 Census Advance Report).

On the peninsula, small residential strip developments along main roads are common, as are small housing developments and mobile home parks located near vast tracts of agricultural lands.

On the Outer Banks and Roanoke Island, intensive residential development is observed in many townships. High density Mobile Home Parks and Single-unit Housing of varying types are typical of the Residential category breakdown to Level III (see preceding section). Six units of residential areas are defined for mapping on the Outer Banks at Level III:

111. Mobile Home Park

112. Single-unit Housing in Open Sand Area

113. Single-unit Housing in Grass and/or Shrub Area

114. Single-unit Housing in Forested Area

115. Area Transitional to Residential (streets and drives but no houses, etc.)

116. Single-unit Housing on Man-made Land

12. Commercial and Services. These areas are used predominantly for the sale of products and services and include urban business districts, shopping centers, commercial strip developments, and all associated buildings, driveways, warehouses, parking lots, landscaped areas, and waste disposal areas. Marinas and campsites are an important part of this category. Institutional land uses such as Hospitals, Schools, and Churches are also included as a further refinement in category.

On the Outer Banks, nine units of Commercial and Services are defined for mapping at Level III:

120. Multi-unit Dwelling (including hotels, motels, apartments, and condominiums with associated restaurants and piers)

121. Fire Station and Rescue Squad

122. Police Department

123. Hospital, Clinic, or Medical Office

124. Emergency Shelter (established by the North Carolina Division of Civil Preparedness)

125. School

126. Marina and/or Water Access Ramp

127. Campground

128. Church

13. Industrial. This includes a wide variety of industrial land uses. Heavy industries include lumbering, concrete and septic tank manufacturing, small chemical plants, and one fish trawler and dredge manufacturer. The lumber and pulp industry employs more people than any other single industry. Weyerhaeuser, located in Martin County just west of Plymouth (Washington County) employs over 2,000 people, whereas no single lumbering operation within the 4-county area employs more than 250 people (Directory of N. C. Manufacturing Firms, 1979-1980). There are several light industries that design, manufacture, or assemble products including skids and pallets, wooden handles, clothing, yarn, soft drinks, and seafood products.

Small industries located within more built-up areas may be difficult to separate from Residential or Commercial and Services areas. Larger industrial areas such as lumber and pulp mills, with stockpiles of raw materials, waste disposal areas, and transportation facilities are more easily visible on aerial photography.

14. Transportation, Utilities, Communications, and Information. This category occurs to some extent within all other Urban and Built-up Land categories, and within others as well. Unless they can be mapped separately at whatever scale is being employed, such land uses are usually considered an integral part of the larger category within which they are found. This category includes electric and gas utilities, airstrips, sewage treatment facilities, and others. Two fairly extensive areas of the Dare County mainland (approximately 7 square miles) also come under this land use category; these are the Air Force and Navy bombing ranges located west of Stumpy Point Bay.

On the Outer Banks, six units of Transportation, Utilities, Communications and Information have been mapped at Level III:

140. Weather Station (Nat. Oceanographic and Atmospheric Admin.)

141. Electric and Gas Utility

142. Telephone Company Field Office and Microwave Tower

143. Water Supply Tower or Sewage Treatment Facilities

144. Airstrip or Helicopter Pad

145. Ferry Pier

15. Industrial and Commercial Complex. This land use category includes industrial and commercial land uses that typically occur together and are often called "Industrial Parks." Because such functions are wholesaling, warehousing, and even retailing often occur in the same buildings, or close by, a more inclusive title for this category was adopted.

16. Mixed Urban or Built-up Land. This category is used for a mixture of Level II Urban or Built-up Land where individual uses cannot be separated at mapping scale. When the intermixed land use or uses total less than one-third of the particular area, the land use category appropriate to the dominant use is used. This category was not used very often in mapping the Albemarle-Pamlico peninsula, because population densities are very low. The various types of Urban or Built-up Land can usually be separated at mapping scale of 1:24,000.

17. Other Urban or Rural Built-up Land. This category includes zoos, parks, cemeteries, and golf courses within an urban or rural setting, as well as undeveloped land within an urban setting. Undeveloped land such as large recreation areas and parking areas for beach access may be under very intensive use. These areas may not contain structures, but terms such as 'vacant land' suggest a refinement in categorization that is not discernible from the aerial photography. On the mainland this category was not used very often; the most frequent usage was for small urban or rural cemeteries and occasionally for small water control structures (e.g., pumping station). On the Outer Banks, however, this land use category was used more often because of higher population densities and intensive recreational usage of large open areas. Six mapping units are utilized at Level III. These are:

171. Cemetery

172. Golf Course (including driving ranges/miniature golf)

173. Intensely Used Recreational Area (such as large parking lots for beach access, tennis courts, water slides, fishing piers, or other such facility not closely integrated into another land use category)

174. Water Control Structure

175. Undeveloped Land within an Urban Setting

176. National Historic Site/Monument

2. Agricultural Land

This division can be broadly defined as lands used primarily for producing food and fiber. Agricultural Land has increased dramatically in the last ten years with the large scale clearing of previously wooded lands.

On high altitude photography, striking geometric patterns are formed by cleared land bordered by intersecting drainage canals and their associated roads. Medium altitude (-12,000 feet) aerial photography was used to distinguish between cleared agricultural land, and cleared areas where the intended future use was unpredictable. Areas which have been planted or reveal evidence of recent tilling have been categorized as Agricultural Land. Areas that may have been cleared for intended agricultural use at one time, but are no longer under cultivation and are reverting to brush, are included within Transitional Areas (76) or Disrupted Grass and/or Shrub Wetlands (614). Near Lake Mattamuskeet, some wetlands are seeded and utilized to produce food for wild fowl. These areas are included in the Cropland and Pasture category (21). Four categories of Agricultural Land are mapped at Level II:

21. Cropland and Pasture. This category includes harvested croplands, cultivated summer-fallow or idle croplands, land where crop failure has occurred, croplands planted in soil-improvement legumes and grasses, and pasturelands.

Cropland and Pastures are grouped togehter as one unit because a high degree of accuracy and uniformity in their separation is not possible from the aerial photographs alone. On the peninsula, First Colony Farms' land use projections for 1975-1981 indicate that 10,000 acres were to have been cleared for pastureland and 80,000 to 100,000 acres cleared for cropland by 1981 (Coastal Zone Resources Corp. 1976).

Agricultural statistics (Table 9) indicate that a total of 206,730 acres of cropland were harvested in the 1979-80 season. This figure represents a decline of 7,060 harvested acres from 1978-79. On a county-by-county basis, the harvested acreages from the 1980 season are 83,280 acres for Washington County, 77,100 acres for Hyde County, 45,440 acres for Tyrrell County, and 900 acres for Dare County. The gross tonnage of mixed fertilizer and fertilizer materials shipped to the counties (Table 10) roughly parallels the distribution of figures reported for harvested acreage in each county.

22. Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas. Tree nurseries that provide seedlings for pulp and timber plantations are included in this category. Nurseries and horticultural areas are also included; however, where such operations may be enclosed in greenhouses, or are very small scale, they are classified under Other Agricultural Lands (24). Orchards, groves, and vineyards are not abundant in the study area.

Table 9. Agricultural Statistics for Crops Harvested during the 1979 and 1980 Season. (Figures indicate total acreage harvested.†)

CORN FOR GRAIN	1979	1980	IRISH POTATOES	1979	1980	WHEAT FOR GRAIN	1979	1980
Oare	500	100	Oare	*	*	Oare	**	**
Hyde	30,500	27,750	Hyde	*	*	Hyde	2,550	3,740
Tyrrell	16,400	15,250	Tyrrell	1,200	1,880	Tyrrell	560	860
Washington	35,650	32,300	Washington	55	45	Washington	2,430	3,540
SOYBEANS (BEANS)	1979	1980	SORGHUM GRAIN	1979	1980	OATS FOR GRAIN	1979	1980
Oare	450	800	Oare	**	**	Oare	**	**
Hyde	43,900	43,500	Hyde	810	720	Hyde	**	**
Tyrrell	28,600	27,100	Tyrrell	**	**	Tyrrell	90	70
Washington	44,650	43,600	Washington	90	70	Washington	**	**
PEANUTS	1979	1980	CORN FOR SILAGE	1979	1980	BARLEY FOR GRAIN	1979	1980
Oare	--	--	Oare	**	**	Oare	**	**
Hyde	--	--	Hyde	900	1,000	Hyde	**	**
Tyrrell	110	110	Tyrrell	**	100	Tyrrell	180	70
Washington	3,070	3,050	Washington	200	200	Washington	90	100
SWEET POTATOES	1979	1980	ALL HAY	1979	1980	TOTALS	1979	1980
Dare	*	*	Oare	**	**	Oare	950	900
Hyde	*	*	Hyde	400	400	Hyde	79,060	77,110
Tyrrell	40	40	Tyrrell	**	**	Tyrrell	47,170	45,440
Washington	25	25	Washington	350	350	Washington	86,610	83,280

*Counties with less than 20 acres not published.

**Counties with less than 50 acres not published.

†Oata obtained from Agricultural Statistics. Released: September 1981, North Carolina Crop and Livestock Reporting Service, Raleigh, North Carolina.

Table 10. Fertilizer Tonnage Report.* (Mixed fertilizer and fertilizer materials shipped to counties, July 1, 1979 - June 30, 1980.†)

	Mixed Fertilizer	Fertilizer Materials	Total
Dare	102	8	110
Hyde	13,573	8,609	22,182
Tyrrell	6,842	2,505	9,347
Washington	16,211	9,981	26,192

*Excludes lime and landplaster.

†Data obtained from Agricultural Statistics. Released: September 1981, North Carolina Crop and Livestock Reporting Service, Raleigh, North Carolina.

23. Confined Livestock Operations. This category includes large specialized livestock production enterprises including confined beef and dairy cattle feeding operations, large poultry farms, and swine feeding operations. Tyson Carolina Farms owns and operates confined beef and swine feeding lots and pasture operations in northeast Washington County and northwest Tyrrell County. First Colony Farms has not been involved in hog raising operations since August, 1977, and by January of 1980, had ceased to own or hold leases on any cattle operations (R. E. Eiland, FCF, 1982 pers. commun.). Livestock statistics for 1979-80 (Table 11) indicated that 166,000 hogs, 10,000 chickens, and 17,600 cattle were produced on farms on the peninsula. Washington County accounted for 68 percent of the hogs, 100 percent of the chickens and 36 percent of the cattle.

Confined Livestock Feeding Operations generally consist of one or more long rectangular shelters, feed silos, and animal waste treatment impoundments that are readily identifiable on medium altitude aerial photography. These areas are of particular interest because of the large concentration of organic wastes associated with confined feeding operations and the potential for these areas to become pollution point sources for nitrates and phosphates.

24. Other Agricultural Land. This category includes all agricultural land uses that are associated with the previously mentioned major categories (21, 22, and 23). It can include farmsteads, temporary holding areas for livestock, corrals, and small farm ponds. Farm ponds and other small impoundments are simply outlined and labeled "w" (water) on both map series. For simplicity, canals and ditches constructed to drain agricultural lands are not included as part of the Land Use and Land Cover map series. These features are included as part of the Drainage and Bathymetry map series.

In the study area, Other Agricultural Lands are primarily farmsteads. Aerial photographic criteria for separation of farmsteads from nonagricultural rural residences include the presence of farms, heavy farm equipment, storage sheds, silos, and other farm outbuildings. Some error is inherent as these were not field checked.

3. Rangeland

Traditionally, rangelands have been defined as lands where the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs. Most rangelands in the United States occur in the Great Plains region, from Texas north through the Dakotas. In the USGS classification system, the definition of Rangeland was extended to include certain areas in the eastern United States that are commonly called brushlands. Only one of the three categories described in this system is applicable to this atlas. The only Rangeland category mapped occurs on the Outer Banks.

33. Grass and/or Shrub Brushland. When more than one-third of the ground surface in a specific area is covered by herbaceous and/or shrub-brush species, it is placed within this category. Density of vegetation as well as the relative proportions of grasses and shrubs are extremely variable in this unit.

Table 11. Agricultural Statistics for Livestock on Farms, 1979-1980. (Figures refer to total number of head per county.†)

HOGS	1979	1980	CHICKENS	1979	1980	ALL CATTLE	1979	1980
Dare	*	*	Dare	*	*	Dare	*	*
Hyde	13,500	12,700	Hyde	*	*	Hyde	7,800	8,400
Tyrrell	41,000	39,000	Tyrrell	*	*	Tyrrell	2,100	2,300
Washington	113,000	114,300	Washington	10,000	10,000	Washington	6,400	6,900

BEEF COWS and heifers that have calved.			MILK COWS and heifers that have calved.		
	1979	1980		1979	1980
Dare	*	*	Dare	*	*
Hyde	1,600	1,700	Hyde	800	700
Tyrrell	900	1,000	Tyrrell	*	*
Washington	2,100	2,200	Washington	300	300

†Data obtained from Agricultural Statistics. Released: September 1981, North Carolina Crop and Livestock Reporting Service, Raleigh, North Carolina.

*Counties with less than 200 milk cows, 500 beef cows, 1,000 total head of cattle, 1,000 hogs and 500 chickens are not published.

On the peninsula, grass and shrub areas often occur on disturbed lands where the water table is at or near the surface for much of the year. Accordingly, these areas are classified as Grass and/or Shrub Wetlands (614) rather than Brushlands. On the Outer Banks, grass and/or shrub areas that occur on poorly drained soils are mapped as Intradune Complex Grass and/or Shrub Wetlands (616).

This mapping unit occurs behind the crests of the primary dunes, on droughty to moderately well-drained sands. Vegetative cover is dominated by grasses on the ocean side but grades into shrub thickets toward the sounds. The more common species include American beachgrass (*Ammophila breviligulata*), little bluestem (*Andropogon scoparius*), sea oats (*Uniola paniculata*), and running beachgrass (*Panicum amarum*). In areas more protected from salt spray, shrubs and stunted trees such as yaupon holly (*Ilex vomitoria*), wax myrtle (*Myrica cerifera*), the silverling or eastern baccharis (*B. halimifolia*), and live oak (*Quercus virginiana*) become established. Grass and/or Shrub Brushland is subdivided into the following four Level III mapping units:

1) Grass-dominated (g) - Grasses form 80 percent or more of total vegetation.

2) Grass and Shrub Mixture (gs) - Grasses make up 50 percent to 80 percent of the total vegetative cover; shrubs from 20 percent to 50 percent of the total vegetative cover.

3) Shrub-dominated (s) - Shrubs comprise from 50 percent to 80 percent of the total vegetative cover.

4) Shrub Thicket (st) - Dense, closely packed shrubs cover more than 80 percent of these areas.

4. Forest Land

Forest Lands are stocked with trees that can be used for production of timber or other wood products. Tree-crown areal density (crown closure percentage) is 10 percent or more. Such lands exert an influence on the climate/water regime. In the study area, Forest Lands occur on either moderately to well-drained mineral soils or ditched and managed shallow organic soils. Although Forest Land generally can be identified fairly easily on high-altitude imagery, it is sometimes difficult to delineate the boundary between Forest Land and other categories of land use, particularly Forested Wetland. In an area such as the Albemarle-Pamlico peninsula, closed tree canopies generally obscure soil moisture characteristics, and other data must often be used to separate "upland" forest or managed forest (Forest Land) from Forested Wetland.

During the period between 1963 and 1973, commercial forested lands on the northeastern Coastal Plain of North Carolina had decreased by more than 3 percent. More than half of this loss of forested areas was a result of conversion to agricultural land, primarily in those counties south of the Albemarle

Sound. On the peninsula, the loss of commercial forest was attributed primarily to a single land transaction involving a major wood-using company. Table 11 gives the 1974 statistics for forested areas by forest type and ownership. More recent statistics are not available at time of writing (Spring 1982). It should be noted that some commercial forest may include areas that are mapped as Forested Wetlands (see Table 12 "*").

On the peninsula, lands that meet the requirements for Forest Land and also for the Urban or Built-up division have been included with the latter. However, on the Outer Banks, an area that meets both of these land division specifications may be given a Level III compound designation. Three types of Forest Lands are mapped at Level II:

41. *Deciduous Forest Land*. This category includes all non-wetland forested areas having a predominance of trees that lose their leaves at the end of the frost-free season. In the study area such trees would include several species of oaks (*Quercus*) and hickories (*Carya*), as well as the black cherry (*Prunus serotina*), tulip poplar (*Liriodendron tulipifera*), flowering dogwood (*Cornus florida*), and many others. This land cover category generally excludes areas where the tupelo gum (*Nyssa aquatica*), black or swamp gum (*N. sylvatica var. biflora*), bald cypress (*Taxodium distichum*), or other deciduous species more characteristic of wetland areas occur. Loblolly pine (*Pinus taeda*) may also occur with these deciduous species. Non-wetland Forest Lands dominated by deciduous species are not common in the study area.

42. *Evergreen Forest Land*. This category includes all non-wetland forested areas in which the dominant trees are those which remain green throughout the year. In the majority of such forests in the continental United States, coniferous (needleleaf) species, rather than broadleafed evergreen species, are dominant. However, Evergreen Forests in the study area include peninsular upland pine and broadleaf-evergreen dominated forest lands, managed pine plantations (whether on naturally or artificially drained soils), and the maritime forests of the Outer Banks.

Fast-growing loblolly pine is the most important native species and is widely planted on the peninsula. In some small areas, slash pines (*Pinus elliottii*), a species native to more southern parts of the Atlantic Coastal Plain, have been planted. Understory subdominant deciduous species include Southern red oak (*Quercus falcata*), beech (*Fagus grandifolia*), tulip poplar, flowering dogwood, and many others.

In the maritime forests of the Outer Banks and in the forests on Roanoke Island, an evergreen oak species, the live oak, is often a dominant form. Other important evergreen species in the maritime forests include loblolly pine, American holly (*Ilex opaca*), and wild olive (*Osmanthus americanus*). Deciduous species include the ironwood tree (*Carpinus caroliniana*) and the flowering dogwood.

Stands dominated by a single evergreen species more characteristic of a Swamp Forest community, such as the Atlantic white cedar (*Chamaecyparis* thyoides), are grouped with Forested Wetland (see 611, 6112). Other poorly drained lands dominated by pines with a subcanopy of hardwoods or shrubs are also grouped with Forested Wetland (see 611, 6113, 615).

Table 12. Forestry Statistics for the Northern Coastal Plain of North Carolina, 1974.†

Area (Acres) of Commercial Forest Land by Forest Type Group and County

	Longleaf Slash	Loblolly Shortleaf	Oak-Pine	Oak-Hickory	Oak-Gum* Cypress	Total
Dare	--	52,145	41,167	--	63,114	156,426
Hyde	2,581	172,204	7,745	7,743	54,591	244,864
Tyrrell	--	87,276	30,589	8,698	86,848	213,411
Washington	--	38,000	5,225	10,616	62,621	116,462

Area (Acres) of Common Forest by Ownership Class and County

	Nat'l Forest	Misc. Fed.	State	County & Muni.	Forest Indus.	Farmer	Misc. Corp.	Private Individ.	Total
Dare	--	--	--	--	--	--	--	156,426	156,426
Hyde	--	14,256	12,850	--	39,635	46,468	82,613	49,042	244,864
Tyrrell	--	--	--	--	39,428	17,398	5,800	150,785	213,411
Wash.	--	8,264	1,096	104	41,685	33,961	7,838	23,514	116,462

†Data obtained from, "Forestry Statistics for the Northern Coastal Plain of North Carolina, 1974," by R. L. Welch and H. A. Knight, USDA Forest Service Resource Bulletin SE-30, Sept. 1974.

*This type of forest land was mapped as Forested Wetland (Swamp Forest) in the atlas project. Also, some pine-hardwood areas on organic soils are mapped as Swamp Forest if canals (and other evidence of managed forestland) were not discernible.

43. Mixed Forest Land. This category includes all non-wetland forested areas where both evergreen and deciduous trees are growing and neither predominates. When more than one-third intermixture of either evergreen or deciduous species occurs in a specific area, that land is placed in this category. Areas of this forest category occur primarily in the western part of the peninsula and are not extensive. Species include loblolly pine and more upland hardwoods, such as the white oak (Quercus alba), the Southern red oak and hickories such as the mockernut (Carya tomentosa). Species composition varies widely depending on site conditions.

5. Water

There are no categories of Water (5) labeled with numbers on any of the map series. Larger water bodies (sounds, lakes, rivers, and streams) are labeled by name on the topographic quadrangles (base maps). Small impoundments or ponds are labeled "w" on the overlays if these are not present on the base maps. Canals, ditches, and channeled portions of streams are included on the Drainage and Bathymetry map series. This was done because the complexity of the artificial drainage systems would have obscured other land use and cover categories if it had been included.

6. Wetland

A Wetland is defined as an area where the water table is at, near, or above the ground surface for a significant part of most years. The hydrologic regime is such that a variety of aquatic or hydrophytic vegetation, or water-tolerant woody vegetation, is usually established, although Nonvegetated Wetlands (e.g., tidal flats, etc.) represent another variation. Wetlands are generally associated with topographic lows or depressions and are located along estuarine shorelines, margins of streams, or floodplains of rivers. However, in the study area, pocosins are very prevalent wetland ecosystems. They are dominated by species of shrubs and characteristically contain pond pine (Pinus serotina) as the only well-established tree species. Pocosins occur on peat "domes" that have built up in blocked stream valleys and subsequently have spread over adjacent interstream divides (Ingram and Otte 1982; Otte 1981).

Recent panchromatic aerial photography, the Tyrrell County natural areas inventory maps (McDonald and Ash 1981), and North Carolina Division of Forestry Pre-Attack Maps provided the primary sources of information for distinction of Wetlands from other vegetative cover. Detailed soil surveys provided supplemental information helpful in identifying and classifying Wetland areas.

Wetlands drained for any purpose are categorized according to their intended use. Where the future use cannot be anticipated, these areas are classified as Transitional Areas (76). Wetlands managed for waterfowl food production are included in the Cropland and Pasture (21) category. If drained and managed former wetland is allowed to return to its natural state, classification reverts to the Wetland division.

In the USGS classification system, there are two categories of Wetland at Level II:

61. Forested Wetland. This category is dominated by woody vegetation and includes a diverse number of community types. Forested wetlands are mapped at Level III, and in two instances, at Level IV. A natural areas inventory of Tyrrell County by McDonald and Ash (1981) provided the basis for the classification system developed for Forested Wetland.

Four mapping units of Forested Wetland are defined for use at Level III:

611. Swamp Forest. These Wetlands occur on the floodplains of the major rivers and streams, as well as on interior portions of the peninsula where the underlying soil is transitional between that of moderately well drained agricultural soils and very poorly drained organic soils. Many different community types occur within the Swamp Forest mapping unit, including gum-cypress or cypress-gum swamps, mixed hardwood bottomland swamps, Atlantic white cedar swamps, and various community types that include loblolly pine as a dominant species.

Cypress-gum swamps occur on nearly continuously flooded deep organic soils. The largest expanse of such Swamp Forest occurs on the south shore of the Albemarle Sound in Washington County. Black gum becomes more dominant on sites with a shorter hydroperiod. Under normal conditions the water table is at or above the soil surface from November to April.

Mixed-hardwood bottomland swamps occur along rivers or streams on land that is usually flooded only seasonally, usually in late winter and early spring. Red maple, hickory, water ash (Fraxinus carolineana), and a very diverse assemblage of hardwoods are part of this type of Swamp Forest.

Stands of almost pure Atlantic white cedar will grow on deep, wet organic soils where water does not stand for appreciable periods of time. In the study area, particularly in eastern Tyrrell County, hundreds of acres of such forest have been clear cut. In one stand of cedar, just west of Frying Pan Lake, black gum is the dominant subcanopy species (McDonald and Ash 1981). Atlantic white cedar is thus a part of several Swamp Forest community types, and also occurs, to a much lesser extent, in Evergreen Wetlands.

In some more interior portions of the mainland, particularly in Dare County, the Swamp Forest also includes the "High Brush" or "High Brush Swamps" that occur on shallow organic soils (North Carolina Forestry Service Pre-Attack maps). These areas have a solid canopy of pine and hardwoods, including black gum and some red maple. Gallberry (Ilex spp.), Titi or swamp cyrilla (C. racemiflora), and fetter-bushes (Lyonia spp., Leucothoe racemosa) are common understory species. Many of these areas would be considered "pocosins in transition" by some workers (Richardson et al. 1981, Otte 1981).

On the Outer Banks, some areas of Swamp Forest occur on shallow organic soils in troughs and depressions between forested dunes or between the forested dunes and back island marshes. Dominant vegetation includes bald cypress, sweetgum (Liquidambar styraciflua), black gum, red maple, and also way myrtle and other small trees and shrubs.

Many mapped areas as 611 are dominated by gum or cypress and gum depending on age since last logging. However, it should be emphasized that the Swamp Forest is a broad map unit and includes many different community types. It was possible in many areas to differentiate between swamp forest composed primarily of Atlantic white cedar and mixed pine-hardwood swamp forest. However, in other areas, it was not possible to subdivide this mapping unit using the aerial panchromatic transparencies. Only two swamp forest types are separated at Level IV:

6112. The Atlantic White Cedar Swamp Forest -- is a Swamp Forest with 50 percent or greater dominance of Atlantic white cedar. Less dense stands are simply mapped as Swamp Forest (611).

6113. The Pine-Hardwood Swamp Forest -- usually occurs in low-lying interior areas on the peninsula that are slightly better drained than the cypress-gum type of Swamp Forest. Pine-Hardwood Swamps usually occur on very poorly drained mineral soils, mineral soils with a thin organic layer, or shallow organics with sandy subsoils. However, from November to April, the water table is still at, or near, the surface. Dominant species in these Forested Wetlands are loblolly pine, which comprise the canopy, with a subcanopy of water-tolerant hardwoods such as black gum, sweet gum, and red maple (McDonald and Ash 1981).

On the Outer Banks, Pine-Hardwood Swamp Forest may occur on very poorly to poorly drained sandy soils, on flats or in depressions between forested dunes. The water table is at or near the surface during wet seasons. Areas adjacent to the sounds are occasionally flooded by wind tides.

614. Grass Cane and/or Shrub Wetland. These Wetlands have an extremely high dominance (90 percent) of reedy grasses and/or low, woody brush vegetation. The more important species include the reedy grass called switch cane (Arundinaria gigantea) and shrubs such as gallberry, zenobia (Z. pulverulenta), and swamp cyrilla. Stunted pond pines may also be present. Most of these areas have been logged, burned over (sometimes repeatedly), or have had the natural stands of pond pine destroyed by storm flooding. Some areas mapped as 614 were clear cut in recent years and ditched for agricultural purposes but have since been abandoned.

At mapping scale it was not always possible to separate areas that are dominated by reedy grasses from those dominated by shrubs. If data were available to separate large areas of grass from shrubs, those areas are labeled on the map overlay.

These areas are grouped with Forested Wetlands because of the usual abundance of woody vegetation. Most of these areas are originally Evergreen Wetland (615) but are placed within this mapping unit because they have been altered in some way, disrupting several succession and ecosystems processes (hydrologic flux). They may revert to the pocosin (Evergreen Wetland) ecosystem if no further disruptions occur. The use of this category was necessary to indicate extent of such areas at time of mapping. This type of disrupted wetland would be considered a "pocosin in transition" by Richardson et al. (1981).

615. Evergreen Wetland. This wetland usually occurs on organic soil and is characterized by a very thick to impenetrable shrub layer. Though the community composition can vary considerably, the most important species include pond pine, swamp cyrilla, zenobia (honeycup), gallberry, loblolly bay (*Gordonia lasianthus*), sweet bay (*Magnolia virginiana*), red bay (*Persea borbonia*), wax myrtle, and other broadleaf evergreens. Abundant Atlantic white cedar and bald cypress are not part of the natural vegetation, although both species occur within the Evergreen Wetland. This category would include those areas variously referred to as pocosins or shrub bogs including pond pine woodlands, bay forests, and pond pine forests, as well as high (tall) and low (short) pocosins. Terminology used in describing Evergreen Wetlands is very variable, and no one system of terminology is universally accepted.

Evergreen Wetlands (615) were refined to Level IV by subdividing into four mapping units. N. C. Forestry Pre-Attack maps, a Tyrrell County national areas inventory (McDonald and Ash 1981), and aerial photographs were used to select these units:

6151. The High Pocosin -- occurs on shallow organic soils, usually 18-24 inches in depth, and has a dense, rather solid canopy of pond pines that may reach 20 to 25 feet in height, sometimes with some larger loblolly bays and red bays. The average height of the shrub canopy is nearly 14 feet; swamp cyrilla, zenobia, loblolly bay, and gallberry are among the more abundant species (N. C. Forestry Pre-Attack maps).

6152. The Dense Low Pocosin -- usually occurs on organic soils exceeding 24 inches in depth. Shrubs have a closely spaced growth habit and average about 4 feet in height. The canopy of short (10-12 feet or less) pond pines may be less scattered than in the Open Low Pocosin but is still open. Occasional clumps of loblolly bay are present. Swamp cyrilla is the most abundant shrub. Gallberry (∿35 percent) is usually more abundant than in the Open Low Pocosin (N. C. Forestry Pre-Attack Maps). The Dense Low Pocosin is the broadest mapping category in terms of variability of the thickness of the pine canopy, but shrub growth is consistently dense.

6153. The Open Low Pocosin -- usually occurs on organic soils exceeding 24 inches in depth. The canopy of short pond pines is much more scattered than in the Dense Low Pocosin. The most important shrubs are swamp cyrilla (∿60 percent) and fetter-bushes (∿40 percent). Lesser species include gallberry, zenobia, leather-leaf (*Cassandra calyculata*), and sheep laurel (*Kalmia angustifolia* var. caroliniana). Plants are scattered and average 3 feet in height (N. C. Forestry Pre-Attack maps).

6154. The Mature Bay Forest -- is a rare community type in the state. Only one example, Buck Island Bay Forest, located just west of Grapevine Bay on the Alligator River in Tyrrell County, has been documented in the study area (McDonald and Ash 1981), although others may exist. This type of remote and relatively undisturbed Evergreen Wetland may be a last holdout for black bear in the State. This Bay Forest has a thick canopy of tall pond pines (∿50 feet), with many large loblolly bays, some red maples and red bays.

The dense shrub layer is made up of sweet gallberry (*Ilex cariacea*), maleberry (*Lyonia ligustrina*), fetter-bush (*L. lucida*), and sparkleberry (*Vaccinium corymbosum*); sweet gallberry and fetter-bush dominate. The soils are deep organics (>5 feet). Such systems are fire controlled and for the canopy to have reached such size, it seems likely that no fires have occurred in the area for at least 60 years (C. B. McDonald, pers. commun.).

This type of Evergreen Wetland would probably be called a "pond pine forest" by some workers (Otte 1981) and might also be better referred to as a "bay pocosin" (C. B. McDonald, 1982, pers. commun.). The tendency of workers to use names that omit the 'Evergreen Wetland' connotation often makes data correlations difficult.

616. Intradune Complex Grass and/or Shrub Wetland. These Wetlands occur on the Outer Banks in usually small areas of poorly drained fine sandy soils in level to slightly depressional flats behind or within the dune complex. During wet seasons, the water table may be above the ground surface. During dry periods, it may drop more than 2 feet beneath the surface.

If these areas are close to the ocean, they are usually vegetated by dense stands of saltmeadow cordgrass (*Spartina patens*) with an occasional wax myrtle. As the distance from ocean spray increases, less salt-tolerant grasses and sedges occur, along with vines such as greenbrier (*Smilax bona-nox*) and Virginia creeper (*Parthenocissus quinquefolia*) and shrubs such as eastern baccharis, wild olive, red bay, and others.

This is a very inclusive mapping unit. Although some of these areas have dense stands of cordgrass and little else, they are included in this category because separation from shrub-dominated areas at mapping scale is not feasible. These areas are grouped with Forested Wetlands because of the usual abundance of woody vegetation.

62. *Nonforested Wetland*. These areas are dominated by herbaceous, wetland vegetation (hydrophytes) or are nonvegetated. Such Wetlands include, but are not limited to, tidal and nontidal fresh, brackish, and salt marshes, as well as nonvegetated sand and mud flats.

Three mapping units of Nonforested Wetlands are defined for use at Level III:

621. Freshwater Marshes. These marshes occur around the edges of lakes, ponds, and along some creeks and streams, upstream from the influence of tides and salinity. These occur on both the Outer Banks and the mainland. In these marshes, the dominant emergents are usually the cattails (*Typha* spp.), associated with bulrushes (*Scirpus* spp.), arrow arum (*Peltandra virginica*), as well as a reedy grass (*Phragmites communis*), rushes (*Juncus* spp.), saw grass (*Cladium jamaicense*), and giant cordgrass (*Spartina cynosuroides*).

622. Salt or Brackish Marshes. Salt or Brackish Marshes fringe large portions of the eastern and southern shores of Dare and Hyde Counties

and are also found along portions of the sound side of the Outer Banks. Some small areas of regularly flooded Salt Marshes are found in the southern part of the peninsula, along the back side of the barrier islands in the vicinity of ocean inlets.

Irregularly flooded Salt or Brackish Marshes are dominated by such narrow-leaved emergents as black needlerush (Juncus roemerianus), saltmeadow cordgrass, and salt grass (Distichlis spicata). Regularly flooded Salt Marshes are dominated by smooth cordgrass (Spartina alterniflora).

623. Nonvegetated Flats. These areas of sand, silt, or mud occur sporadically along the margins of some estuaries, lakes and creeks. Such irregularly flooded Nonvegetated Flats are also found behind the barrier strand on southern Ocracoke and Bodie Islands, and to a lesser extent along the southeast margin of the peninsula. Many are too small to be mapped at a scale of 1 inch = 2,000 feet.

7. Barren Land

Barren Land is comprised of lands with limited capacity for supporting life. Barren Lands include beaches, dunes, and other sandy areas, as well as borrow pits, active peat mining areas, landfills, and other lands in transition from one land use category to another.

Sandy regions that have more than one-third of the surface area covered by vegetation are mapped in the appropriate land cover category. Wet, nonvegetated barren areas are mapped as Nonvegetated Flats (623).

Land may appear barren because of man's activities. When the future use of such a piece of land can reasonably be inferred from the available data sources, the Barren Land category is not used. However, when future usage cannot be determined, inferential errors may be reduced by use of this category.

Four types of Barren Land are mapped at Level II. These are:

72. Beaches. On the mainland part of the study area, most Beaches that occur along the shorelines of the rivers and estuaries are too small to be mapped at a scale of 1:24,000. However, vast expanses of Beaches occur on the ocean side of the barrier island system.

73. Sandy Areas Other Than Beaches. On the mainland, this category is not utilized. However, on the Outer Banks there are abundant dunes that form the most significant part of this category. However, when dunes, sandy ridges, or flats have more than one-third of the land area covered by trees, shrubs, or grasses, they are mapped in the appropriate Forest Land, Rangeland, or Wetland category. Only largely nonvegetated sandy areas are mapped in this category.

75. Borrow Pits and Mines. Both on the mainland and on the barrier island system there are relatively small areas (generally less than 0.2 square kilometer) where sand or other materials, sometimes shell, have been extracted from the ground for roadbuilding or other purposes. Inactive and unreclaimed pits are also included in this category. Unused flooded pits are, however, labeled "w" (water).

The only other lands that fall into this category are peat mining areas on the mainland. Permits for these peat mining operations have been issued for slightly more than 16,000 acres, but less than 400 acres have been actively mined. These permits have been issued to First Colony Farms for 15,012 acres near Lake Phelps in Washington, Tyrrell, and Hyde Counties (only 300 acres have been actively mined) (R. E. Eiland, FCF, 1982, pers. commun.); to American Peat Company for 98 acres south of Pungo Lake in Hyde County; and to Peat Fuels, Inc. for 708 acres near the Pungo National Wildlife Refuge in northwestern Hyde County. One additional peat mining permit is pending. Whitetail Farms is seeking a permit to mine 7,020.8 acres in western Hyde County near the Intracoastal Waterway. Lantern Acres, Inc. was seeking a permit to mine 650 acres in west central Tyrrell County, but this permit application has now lapsed (Jim Smith, 1982, pers. commun.).

76. Transitional Areas. This category is intended for use when an area is in transition from one land use or land cover category to another. Large areas of forest and evergreen wetlands have been cleared for agricultural or other purposes on the Albemarle-Pamlico peninsula. In this report, future land use has been interpreted or predicted wherever reasonably possible, and category 76 was reserved for use only for those cleared or open lands that could not be immediately transferred to another category. Some large areas of category 76 are surrounded by both agricultural fields and managed forestlands. Because future use of these lands could not be adequately determined from the available photography or other data sources, and field checking was not feasible, these areas were placed in category 76. Small areas of this category occur far more frequently than large areas; such small areas are often associated with urban or other construction sites and with landfills or spoil dumps.

Sometimes a dual designation such as 76/6153 is used. This indicates that an area of cleared land (76) is recovering pocosin characteristics but was still in a transition phase at the time that the aerial photographs used in updating were taken. If, on the other hand, these numbers had been reversed (6153/76), this would indicate that an area of pocosin land (6153) was in a process of transition (being cleared, ditched, or altered in some way) at the time the aerial photographs were taken.

DRAINAGE AND BATHYMETRY MAP SERIES

Artificial Drainage Systems

Although drainage pattern alteration on the peninsula began in the late eighteenth century (see pages 43-44), only in the last ten years have the changes been extensive. A widespread system of canals, ditches, and associated roads was present in the area prior to 1970. However, large scale clearing and ditching of forest and evergreen wetlands by corporate farm industry since 1973 has resulted in numerous additions to this artificial drainage system.

Although efforts to alter the drainage regime to make the land more suitable for agriculture began about 250 years ago, only in recent years have advances in heavy equipment technology and corporate farm management made large-scale changes feasible.

Preparation of Land

As the first step in preparing land that has not previously been ditched, main canals are spaced about one mile apart. The material excavated from the canals is used as road bed fill. Usually another set of ditches is then dug at right angles to the main canals. Depth of these collector canals will depend on the need for road material. Finally, a third type of canal is dug at right angles to the collector ditches; these smaller **V** - shaped ditches are excavated by a power shovel that keeps their dimensions constant (Daniel 1978). A diagram showing this three-way canal system is shown in Figure 19.

Recent aerial photography (1980-1981) shows that field ditches may be spaced as close as 150 feet or as far apart as 350 feet. However, First Colony Farms has recently standardized field ditch spacing at 300 feet (R. E. Eiland, FCF, 1982, pers. commun.). In an idealized situation, approximately 16 to 20 miles of field ditches and three miles of collector ditches drain each square mile of land. By 1974, this artificial system had produced a drainage pattern that was seven to 14 times more dense than natural stream channel densities measured from the mountains to the Coastal Plain, respectively (from Heath 1975). The density of the artificial drainage system has increased considerably since 1974, and this comparison is probably out of date.

Impact of the Artificial Drainage Systems

Artificial drainage systems on the peninsula are designed to prevent ponding of water on land surfaces. Also, such systems help to achieve suitable conditions for seed beds, planting, plant growth, and harvesting on agricultural lands. Artificial drainage can also help to achieve trafficable conditions for other land uses (Skaggs 1980).

Studies of effects of development on hydrology and runoff water quality are few. However, available data suggest that peak runoff rates occur earlier and are three to four times higher on developed than on undeveloped lands. In drought years, there will probably also be small increases in annual runoff. Average water table depths measured in one study were about 22 centimeters deeper on developed than on undeveloped deep organic soil (Skaggs *et. al*. 1980).

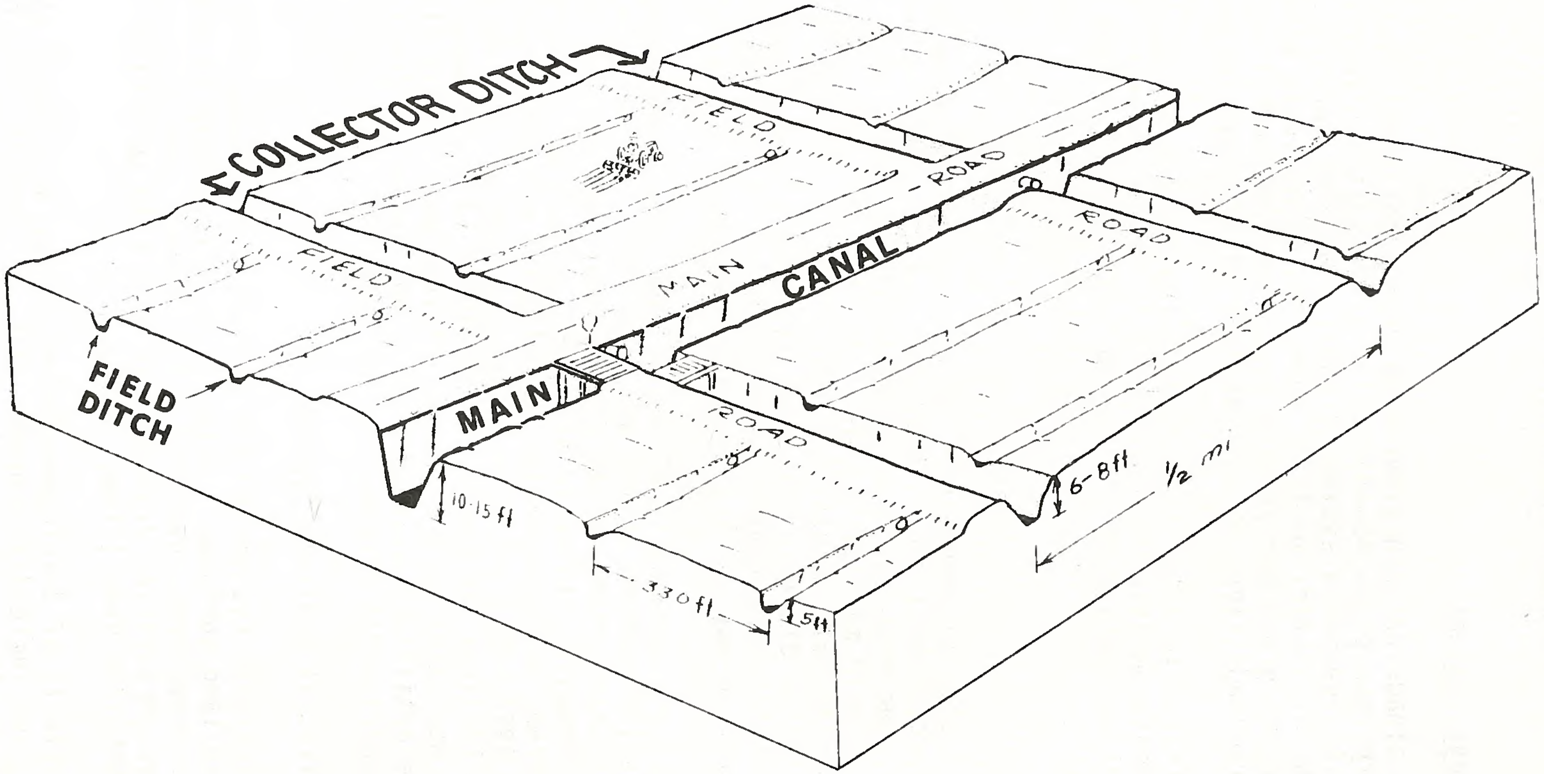

Figure 19. Artificial Drainage Canal System (idealized) Employed by Corporate Farm Industry (from Heath 1975).

Questions about salt water encroachment, subsidence of organic soils and contamination of drainage and estuarine waters by herbicides, pesticides, fecal organisms from pasturelands, and excessive nitrogen, phosphorus, and other elements have been raised but not thoroughly studied. One study suggests that subsidence of organic soils may be greatest just after development and minimal thereafter (Skaggs _et al_. 1980). Such issues are debated, but sufficient data necessary to substantially support or refute either side of an argument are lacking.

Mapping Procedure

Aerial photography flown in November 1980 and April 1981 was used to update the artificial drainage system. All major canals and ditches not present on the USGS 7 1/2 minute topographic quadrangles (updated 1974) were mapped on mylar overlays, using the topographic quadrangles as base maps. Major water bodies such as lakes and rivers were not drafted on the overlays, as they are already present on the topographic base maps.

Channeled or otherwise altered portions of natural stream drainage patterns have been mapped. Canals abandoned since 1974 were indicated by single dashed lines. In rare instances, a single dashed line may indicate that a road (present on the topo base map) is no longer present (on the aerial photographs). These are usually field roads, and they have been destroyed when older canal and ditch patterns have been changed by filling and reditching. Paired lines indicate canals on both sides of an unimproved road. Extremely wide (>40 feet) canals or elongate impoundments are outlined and have closed ends, unless they extend from the edge of one base map to an adjacent map. Smaller canals present on the new photography but not on the topo sheets were mapped. No attempt was made to field check the condition of smaller canals that are located on the topo sheets but could not be discerned in the new photography. This was beyond the scope of the project.

Mapping Categories

Four categories were devised, and these are separated by a thick line on the mylar overlay maps. Ditches already present on the base maps were not indicated on the overlays. To obtain an understanding of the extent of the current artificial drainage system, canals mapped on both overlay and base map must be considered, with the realization that not every ditch was mapped (see FD and ISD "*"). Areas of varying ditch and canal patterns are labeled:

1) Ditched only as indicated

   This category includes areas where all ditches observed on the aerial photographs were mapped. The condition of ditches mapped on the topographic quadrangle base maps, but obscured by vegetation on the photography, could not be assessed without extensive field checking. These canals were left as indicated on the base maps.

2) No ditches

   Some areas are also labeled "no field ditches"; this means canals are as indicated, but no additional ditches are present.

3) FD

This category indicates field-ditched areas where canals are closely spaced at regular intervals of from 150 to nearly 350 feet. Only every fourth or fifth ditch was mapped*. These areas are usually extensive and are typical of much of the recent activity (since 1974).

4) ISD

This category includes areas that are characterized by short (usually less than 2,000 feet), irregularly oriented or spaced ditches, such as those found in some older cultivated areas. Also, extensive areas of long (greater than 2,000 feet), closely spaced, often non-linear ditches are placed in this category when spaced at irregular intervals within a section. This type of ditching is common in areas that are transitional to managed timberlands. As in category (FD), only every fourth or fifth ditch was mapped*.

ACTIVE PROCESSES MAP SERIES

The major discussion of Active Processes deals with the Outer Banks because the barrier island system is the most dynamic part of the study area and is constantly adjusting in response to natural processes. Man's activities dominate surficial processes on much of the peninsula. These activities, such as land clearing and artificial drainage systems; are discussed and mapped under Land Use and Land Cover and Drainage and Bathymetry. Large portions of the sounds have been excluded from this section due to lack of data that could be mapped at 1:24,000. A discussion of natural processes for the sounds is provided in the General Setting section (see pages 11 to 23).

For a discussion of landforms and elevations on the Albemarle-Pamlico peninsula, see the General Setting section (page 8).

Landforms

The Outer Banks of North Carolina extend some 225 miles from Cape Henry south to Bogue Inlet. Major coastal landforms encountered along the Banks consist of a repeated sequence of headlands, barrier spits, and barrier islands (Field and Duane 1976). The prominent Carolina Capes are the headlands of the barrier system and are either attached to the mainland as is the case for Cape Henry, or are separated from the mainland by back barrier sounds as are Cape Hatteras and Cape Lookout. From these headland regions, barrier spits extend in the direction of prevailing longshore currents. The barrier spits are cut by one or more inlets, and these detached segments form barrier islands.

Barrier spits and barrier islands are relatively narrow features of the coastline. At the northern extremity of Hatteras and Ocracoke Islands, long stretches are less than 0.25 miles wide, while much of the remaining barrier strand is less than 0.5 miles wide. Maximum widths of between 2.5 and 3 miles occur at Cape Hatteras, Collington and Kitty Hawk, where a series of relict ridges parallel to the coast widen the land mass. Wider sections also occur in the vicinity of active and relict inlets, and where overwash fans protrude along the sound side.

Elevation

Elevations are generally less than 10 feet, except where man-made dunes, dune fields, and relict ridges occur. Headland regions usually have somewhat higher elevations. Man-made dunes 8 to 25 feet in elevation lie behind ocean beaches and form an almost continuous ridge from Currituck Spit to Ocracoke Island. Active,nonvegetated back-barrier dune fields with elevations ranging from 10 to 150 feet are restricted to portions of Currituck Spit and Bodie Island. On the south shore of Cape Hatteras, active dune fields behind the beach rise to 45 feet above sea level. The most prominent relict ridges on the Banks are located behind the dune field at Cape Hatteras and attain elevations of more than 60 feet. Discontinuous relict beach and inlet ridges are found elsewhere but are less pronounced and seldom higher than 10 feet.

Inlets

At present, there are seven major inlets along the Outer Banks. From north to south, they are Oregon, Hatteras, Ocracoke, Drum, Barden, Beaufort, and Bogue. A large tidal delta has formed inside the barrier line of each inlet. Seaward tidal deltas are poorly developed, and in most cases, are no more than submerged bars. Three minor inlets are open along Core Banks: Whalebone, Swash, and Sand Island. These inlets are unusually close together, very shallow, and often dry, except at high tide. Tidal deltas on either side are poorly developed.

Historical maps and documents indicate that the inlets presently open have formed recently. The earliest dates for openings of the seven major inlets are given in Table 13. Prior to these openings, several different inlet configurations existed. In the Currituck County portion of the Outer Banks, four inlets were open at various times during the past 350 years. In Dare County, seven inlets were open within this same period, while in Hyde County, two inlets were open (Table 14). Positions of former inlets are marked by recurved inlet ridges, inlet ponds, tidal creeks, and extensive back-barrier shoals and salt marshes preserved as relict features (Fisher 1962).

Table 13. Maximum Period of Time Major Inlets of the Outer Banks Were Open (after Fisher 1962).

Oregon Inlet	1846 - present
Hatteras Inlet	1846 - present
Ocracoke Inlet	pre-1585 - present
Drum Inlet	1722 - 1770; 1933 - present
Barden Inlet	1770 - 1860; 1933 - present
Beaufort Inlet	pre-1585 - present
Bogue Inlet	pre-1585 - present

Geologic Evolution

Headlands, barrier spits, and barrier islands that comprise the Outer Banks were formed during periods of fluctuating sea level, in response to the same coastal processes that continue to reshape them today (Field and Duane 1976). At the onset of the Holocene epoch 15,000 to 18,000 years ago, sea level was approximately 320 feet lower than it is at present (Fairbridge 1960; Curray 1965; Milliman and Emery 1968). The shoreline along the Atlantic coast of the United States was some 40 to 100 miles seaward of its present position (Coleman and Smith 1964). At this point in time, the continental shelf was dry land and probably heavily forested.

Early in Holocene time, at the end of the Wisconsin glacial period, sea level began to rise rapidly as large volumes of water were released from melting ice sheets. As sea level rose and flooded the gently sloping continental

Table 14. Maximum Period of Time Former Inlets Were Open in the Northern Portion of the Outer Banks (after Fisher 1962).

Currituck County	
Old Currituck Inlet	pre-1585 - 1731
New Currituck Inlet	1713 - 1828; 1842 (?)
Musketo Inlet	pre-1585 - 1682
Trinity Harbor Inlet	pre-1585 - 1657
Dare County	
Caffey's Inlet	1770 - 1811
Roanoke Inlet	pre-1585 - 1811
Gunt Inlet	pre-1585 - 1798
New Inlet	1657-1682; 1738-1922; 1932-1945
Loggerhead Inlet	1657-1682; 1843-1870
Chickinacommock Inlet	1657-1682; 1682-1770
Chacandepeco Inlet	pre-1585 - 1672
Hyde County	
Wells Inlet	1840 - 1850
Old Hatteras Inlet	pre-1585 - 1770

shelf, waves scoured sediment from the submerged landscape. These sediments, combined with sediments carried to the ocean by rivers, were distributed along the coast by longshore currents. Finer sediments (silts and clays) were resuspended by waves and coastal currents and carried out to sea where they settled in less turbulent waters. Coarser sediments (mostly sand) remained in the nearshore zone, blocked from seaward transport by wave action (Bruun 1962).

The rate of sea level rise slowed considerably 4,000 to 7,000 years ago and has since continued a slow , but at times, erratic rise (Shepard 1963; Otvos 1970; Riggs and O'Connor 1974). This change probably marks the period when most of the present (or modern) barrier strand shorelines developed (Riggs and O'Connor 1974). By this time, an abundant sand supply had developed in nearshore zones and the adjacent shallow continental shelf, and calm weather waves began to push sand against the shore. As onshore winds moved the sand inland, ridges of sand developed parallel to the coast. Waves and longshore currents continued to smooth out the coast by erosion of irregular features protruding from the shore and deposition of the resulting sediments as spits that developed parallel to the coast, in the direction of prevailing longshore currents (Fisher 1967; Field and Duane 1976).

In the past as now, barrier island development was controlled by: 1) rate of sea level rise; 2) sediment supply in the nearshore zone; and 3) intensity of wave action (Field and Duane 1976, Pilkey et al. 1980). Change in any of these components has a direct effect upon development of the barrier strand. During stillstands of sea level that have occurred intermittently over the past several thousand years, the shoreline prograded seaward forming a series of beach ridges parallel to the coast (Fisher 1967). After long periods of sea level stability, offshore sand supply may have been reduced by waves scouring the adjacent continental shelf below wavebase, effectively stopping forward growth of the beach (Phleger and Ewing 1962). When sea level rise resumed, beach ridges were cut back and the shoreline once more began to retreat. The series of truncated beach ridges on Cape Hatteras, Collington, and Kitty Hawk are vestiges of past stillstands.

Historical Background

Historical descriptions of the original (pre-colonial) condition of the Outer Banks and subsequent changes provide a record of environmental responses to development.

Early Settlements

Prior to 1800, there were large areas of maritime forest on the Outer Banks (Stick 1958, Ansell 1905, Spears 1890). Early historical accounts and topographic maps indicate that the forest belt was discontinuous; vegetation cover was varied; and stands of dense maritime forest were separated from each other by areas of sand sheets, small sand hills, inlets, and former inlets (Fisher 1962, Hennigar 1979). Early colonial settlements on the Outer Banks were located within the forest belt on the sound side, and their distributions were low. Proximity to the forests provided easy access to lumber for construction, rich humic soils for cultivation of food crops, and protection from storms and migrating sand dunes (Stick 1958).

Man's Activities

By the mid-1800's, as the population of the Banks rapidly increased, grazing and logging were intensified, and areas surrounding villages and forests became unstable (Spears 1890, Pinchot and Ashe 1897). Movement of sand started just after the Civil War, and according to Cobb (1906), resulted from cutting of trees for ship timbers. Devegetation and ensuing sand movement were probably due to grazing of horses, cattle, sheep, and goats, in addition to logging (Gibbs and Nash 1961). Most authors agree that by the late 1800's, the forests had been diminished as a result of burial by sand rather than by logging, and that they were in need of protection (Hennigar 1979).

By the late nineteenth and early twentieth centuries, devegetation and shifting sand dunes had become such a problem that villages were abandoned. Ordinary high tides washed over the Banks in places 3 miles or more in length, and residents began to move off the Banks to other areas in the State (Gibbs and Nash 1961, Stratton 1943).

Stabilization Efforts

Erosion control projects on the Outer Banks began in 1904, when several large hunting clubs attempted to protect their property. In 1934, the Federal Emergency Relief Administration began erosion control measures along several miles of beach adjacent to Currituck Sound. In a few months, due to lack of proper study methods, high tides had destroyed the entire effort.

Stabilization efforts were resumed in 1935 by the Civilian Conservation Corps (CCC) and the Works Progress Administration (WPA), under the direction of the National Park Service. The objectives were to eliminate overwash across the barrier islands and to stop the movement of sand dunes encroaching upon remaining forests and villages. Prefabricated sand fences constructed of brush were transported from the mainland and erected over more than 125 miles of coastline, including Hatteras, Pea, and Bodie Islands. About 12 months after the beginning of the project, a linear barrier dune 8 to 25 feet in height had been completed, and regular tidal overwash was stopped. Grasses and shrubs were planted along the bases of dunes and surrounding sand flats. These vegetation efforts succeeded in stabilizing artificial dunes and retarding the movement of sand dunes in interior portions (Stratton 1943, Dolan *et al*. 1973).

With the outbreak of World War II, emergency dune stabilization programs came to a close. Lack of maintenance and frequent storms destroyed much of the work that was accomplished in the late 1930's (Gibbs and Nash 1961). Dune stabilization was resumed in the late 1950's by the National Park Service. The linear dune ridge was rebuilt from Nags Head to the southern tip of Ocracoke, and American beachgrass was planted to stabilize the dunes (Dolan *et al*. 1973).

Dune construction and stabilization continued through much of the 1970's, but despite such efforts, erosion has continued. On March 7, 1962, a northeastern storm with gale force winds accompanied by spring high tides struck the coast. A number of temporary inlets or overwash cuts were formed along Currituck

Spit and Bodie Island in the vicinity of Nags Head. In addition, a new inlet was formed about a mile north of Buxton. Shortly after the storm had passed, these temporary inlets closed. However, 'Buxton Inlet' remained opened for several months and had to be artificially closed. The dune ridge north of Buxton was breached again during a storm in 1973, and a portion of the Hatteras Court Motel was destroyed. At Coquina Beach, this same storm destroyed a bathhouse as waves breached the dunes (Pilkey *et al*. 1980).

Today, long-term benefits of stabilization and dune construction are being questioned. Scientists are concerned that stabilization efforts along the coast may actually increase the extent of damage from future storms (Dolan *et al*. 1973).

Mapping Procedures

The Active Processes maps are divided into two separate series. One set covers the sound and estuarine shorelines of the Albemarle-Pamlico peninsula, and the second covers the Dare and Hyde County portions of the Outer Banks, including Roanoke Island and adjacent nearshore areas. Maps of the peninsular region provide information on shoreline erosion trends and shoal positions; maps of the Outer Banks provide more detailed information on active surficial processes, relict geomorphic (land surface) features, and artificial alterations of the land. Figure 20 shows the USGS 7 1/2 minute topographic quadrangles included in the complete Active Processes Map Series.

Albemarle-Pamlico Peninsula

Baseline data on shoreline positions were taken from revised USGS 7 1/2 minute topographic quadrangles at a scale of 1:24,000. The topographic base maps used were revised between 1951 and 1978, with most of the revisions dated 1974 and 1975. Shorelines were transferred from base maps to interim mylar work sheets, and landmarks such as road and canal intersections were added from both maps and USGS orthophotoquads (1:24,000) as controls. Shorelines were updated using 1981 color infrared (CIR) aerial transparencies at a scale of 1:48,000[1]. Although the scale is smaller, color infrared imagery was used rather than panchromatic (1:24,000) because the CIR imagery provided greater contrast between land and water. An Autofocus[2] was used to enlarge the CIR

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[1] Color infrared transparencies were obtained from the Environmental Protection Agency. The aerial photogrammetric survey was flown in November, 1981, by Kocera and Associates, Inc.

[2] Autofocus is a trade name for an optical reflex system (KA 5179) manufactured by Philip B. Kail Associates for cartographic scale manipulation. The system was modified with a rear projection device that greatly improved the resolution of transparent images.

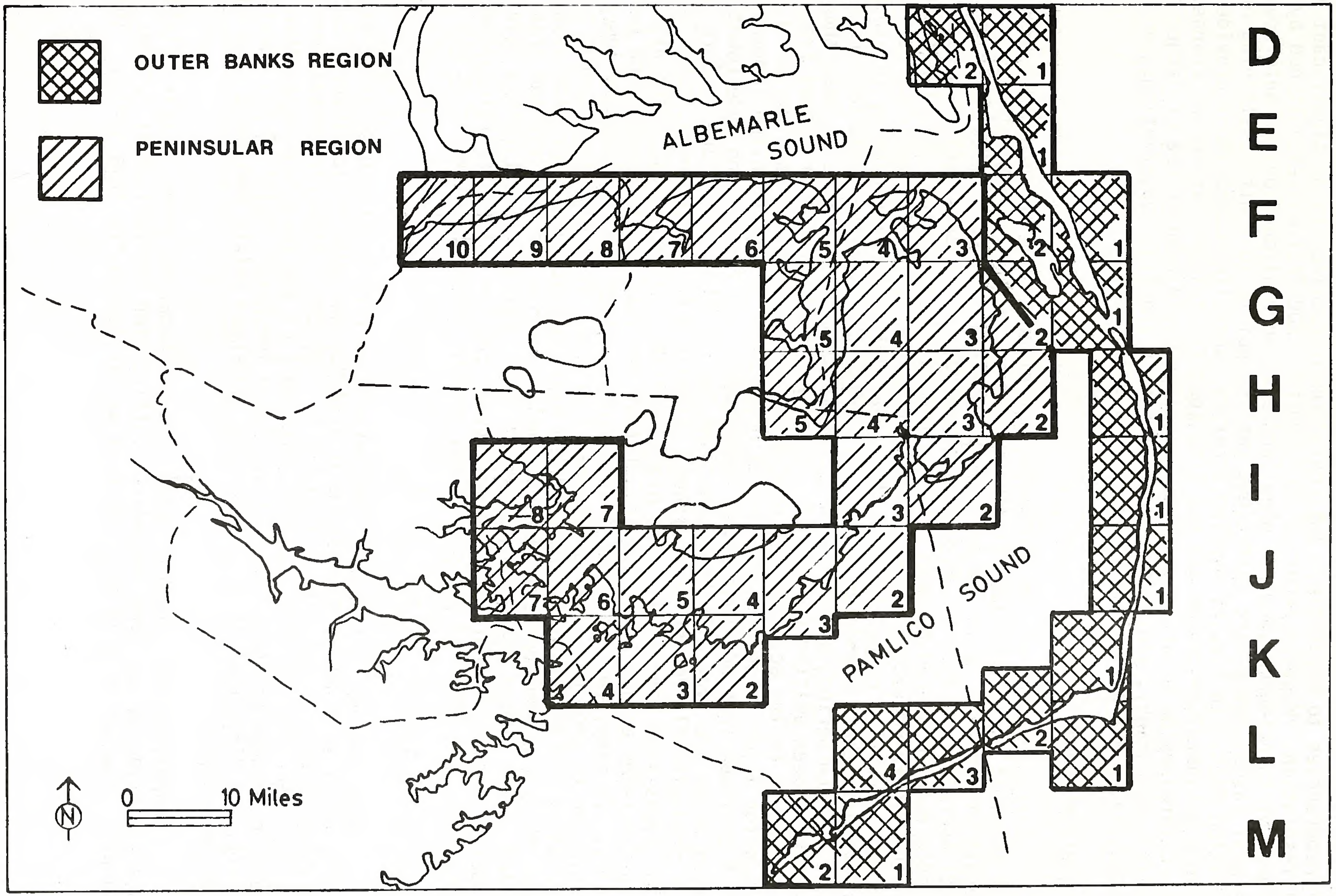


Figure 20. Index to USGS 7½ Minute Topographic Quadrangles (Base Maps) and Overlays Used for Active Processes Map Series.

transparencies to map scale. This enlargement resulted in no significant loss of resolution. Mapping accuracy of ± 100 to ± 200 feet was established by the degree of coincidence obtained when landmarks were aligned on the Autofocus. In most cases, there were sufficient control points to limit positioning errors to ± 100 feet. In view of mapping accuracy, shoreline comparisons provide trends on shoreline change and not site specific rates of shoreline change. The determination of specific rates of change would require use of larger scale aerial photography, additional ground controls and field observations, and consequently was beyond the scope of this project.

Shoreline Trends

Since revision of the USGS maps, shorelines along the peninsula have, for the most part, remained relatively stationary or have retreated as a result of erosion. With few exceptions, accretion is not indicated by the 1981 shoreline positions. Figure 21 summarizes major erosional changes as the displacement measured between former and updated shorelines. Erosion trends in the figure reflect changes that have occurred over different time periods, and consequently, cannot be directly compared from one map overlay to another. To evaluate these trends on a regional basis, the time-frame has been normalized to a uniform period, and shoreline segments that have changes by less than 100 feet have been omitted (Figure 22). High rates of erosion are noted from the Pungo River to the southern end of Croatan Sound and along portions of the Alligator River. The highest erosion rates occur along shoreline segments that protrude into adjacent sounds and rivers. In Tyrrell and Hyde Counties, these areas are typically "low bank" and "marsh" shorelines, and in Dare County, are predominantly "marsh" shorelines. Along the Albemarle Sound, these shoreline types have been shown to be highly erodible (Riggs *et al*. 1978) with erosion rates estimated at 2.6 to 3.1 feet per year (Soil Conservation Service 1975). In many areas these estimated erosion rates are considerably lower than indicated by erosion trends on the map overlays. This disparity cannot be accounted for by position errors in the mapping procedure. The data suggests that shoreline erosion rates are extremely variable and that average erosion rates do not always reflect this variability. Earlier investigators have observed a similar degree of variability in erosion rates, reporting shoreline recession up to 20 feet per year along "marsh" shorelines (Bellis *et al*. 1975).

Outer Banks Region

Baseline data for this series were taken from revised USGS 7 1/2 minute topographic quadrangles at a scale of 1:24,000 and NOAA National Ocean Survey Nautical Charts at a scale of 1:80,000 to 1:40,000. Topographic base maps were revised between 1970 and 1977, with most of the revisions dated 1970. Revised topographic maps were not available for Martin Point (D-1), Jarvisburg (D-2), and Kitty Hawk (E-1) quadrangles; advanced prints were used as a base for these maps.

Shorelines were updated using 1980 panchromatic transparencies (1:24,000 scale) following the same procedures outlined for the peninsular region. A mapping accuracy of ± 70 to ± 100 feet was estimated for this series. The

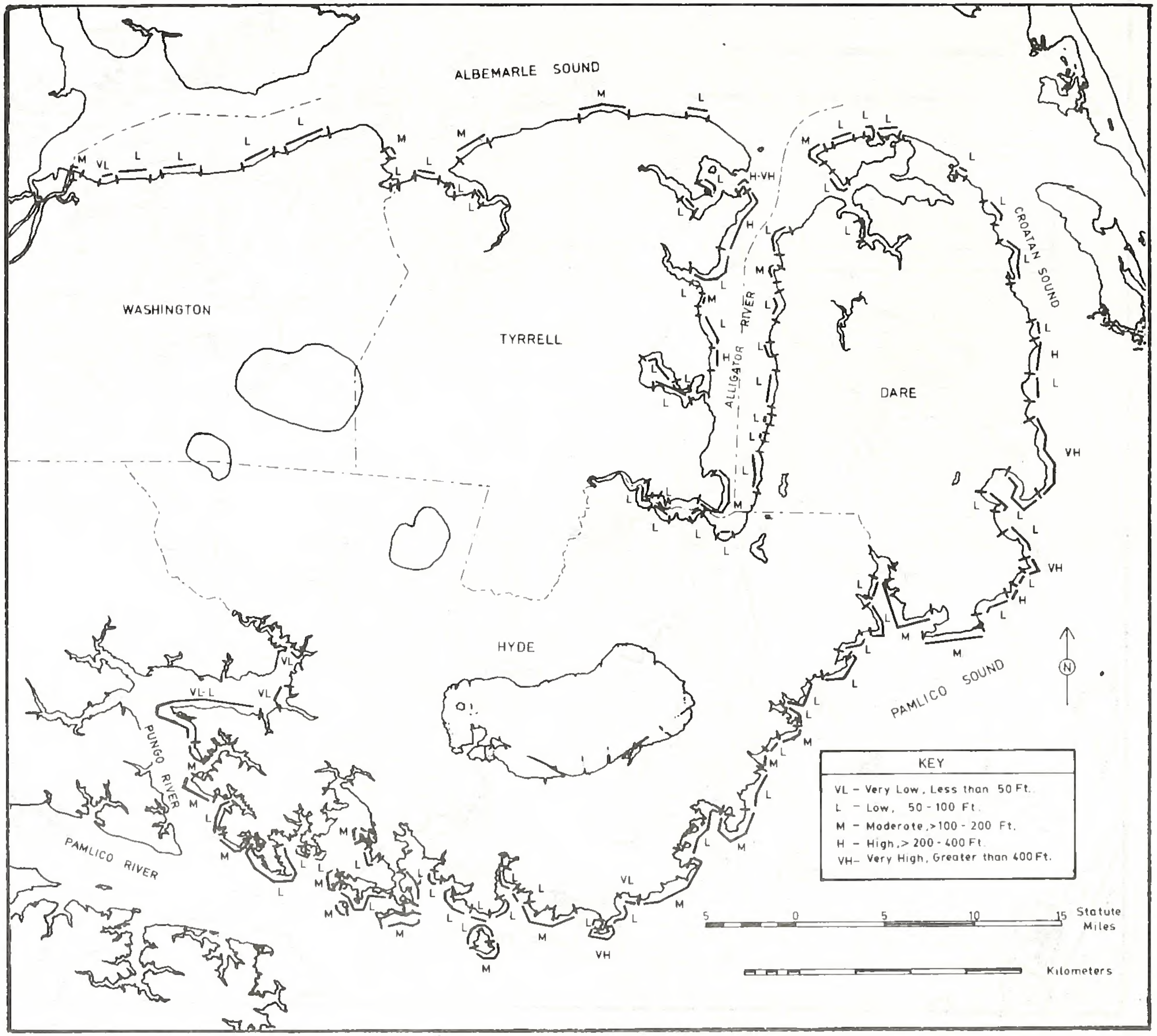

ALBEMARLE SOUND
CROATAN SOUND
PAMLICO SOUND
ALLIGATOR RIVER
PUNGO RIVER
PAMLICO RIVER
WASHINGTON
TYRRELL
DARE
HYDE
N
KEY
VL - Very Low, Less than 50 Ft.
L - Low, 50 - 100 Ft.
M - Moderate, >100 - 200 Ft.
H - High, > 200 - 400 Ft.
VH - Very High, Greater than 400 Ft.
5 0 5 10 15 Statute Miles
Kilometers

Figure 21. Summary of Shoreline Erosion on the Albemarle-Pamlico Peninsula. (Shoreline changes represent the displacement between USGS 7 1/2 minute topographic quadrangles and 1981 infrared transparencies.)

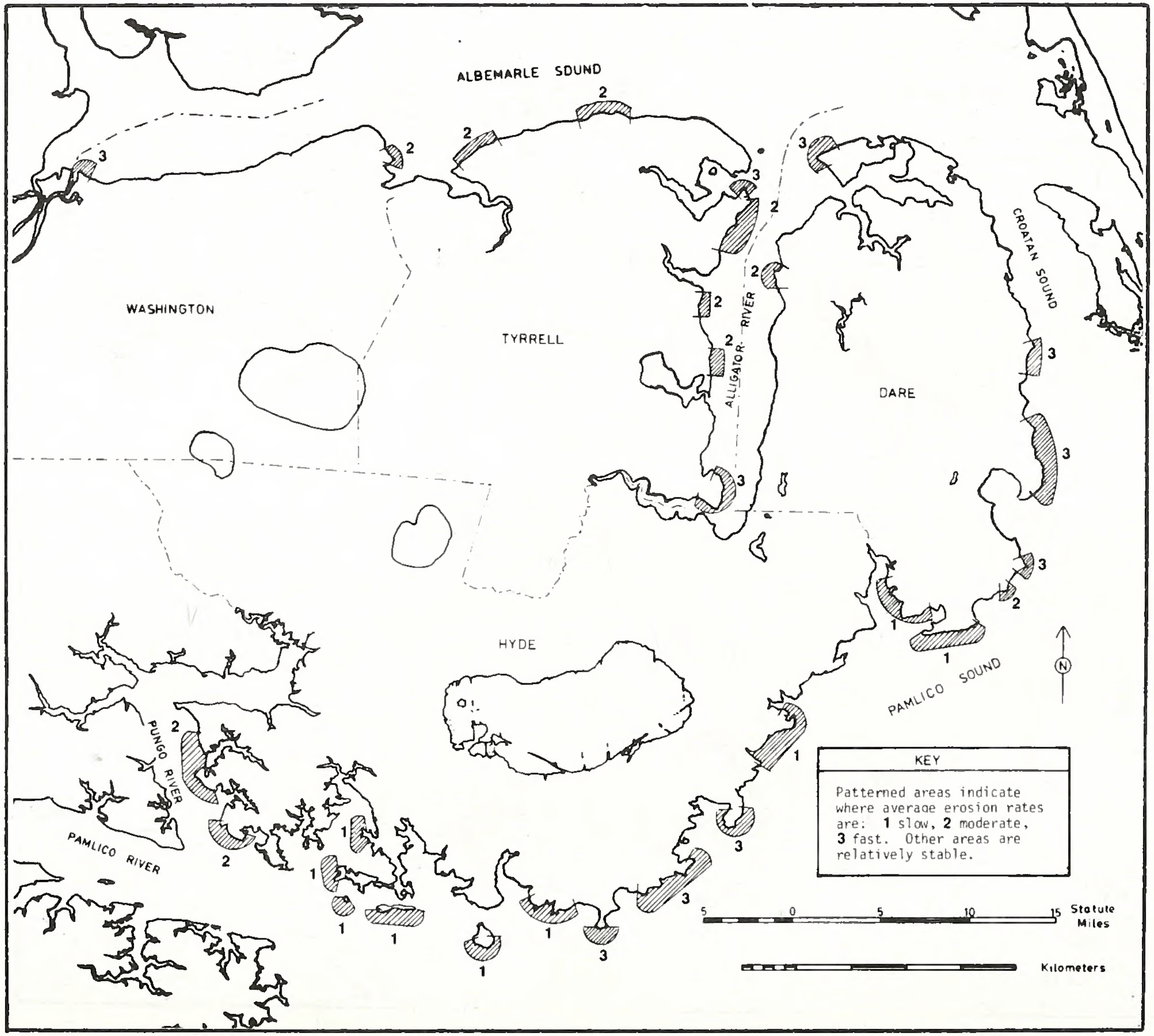


Figure 22. Regional Shoreline Erosion Rates for the Albemarle-Pamlico Peninsula.

improved accuracy results from a higher density of positioning controls (landmarks) along the Outer Banks. Environmental systems, active process units, and man-made features were mapped from the 1980 photography and supplemented with data from technical reports and publications (Dolan et al. 1973, 1979, Pilkey et al. 1980; Soil Conservation Service 1977). Relict features were mapped from topographic base maps and 1980 and 1981 imagery, in addition to data from Fisher (1962, 1967).

Mapping Units

Four environmental systems were mapped on the Active Processes series for the Outer Banks region: 1) the Beach and Foredune, 2) Barrier Ridge and Flat, 3) Salt and Brackish Marsh, and 4) Nearshore Systems (Figure 23). Within each one of these environments, similar physical conditions and processes prevail; mapping units within each system are summarized in Table 15.

Beach and Foredune System

This system consists of the active, nonvegetated sands of the ocean front beaches and includes the forebeach, berm, and foredune zones. The system covers the area from the shoreline landward to the vegetation line at the crest of the primary (frontal) dunes. It extends beyond the primary dunes in areas where storm surge penetration is indicated by sparsely vegetated overwash terraces. On Roanoke Island, this system is limited to a large spit on the extreme north end of the island.

Beach and Foredune soils (SCS soil numbers 1 and 3) are typically well-drained sands and belong to soils of Group 1 (Physical Properties Map Series, see Table 5, page 34). The only beach and foredune soils that are not included in this group are 'tidal flat sands' (SCS soil number 5) that occur on the southern end of Ocracoke Island. These soils belong to Group IV and are similar in texture to Group I but are very poorly drained due to a seasonally high water table and are periodically overwashed by above normal tides.

Barrier Ridge and Flat

This system consists of a variable intermixture of dunes, ridges, elevated terraces, flats, floodplains, interdune marshes, and swales between dunes. On the barrier strand, this system extends from the primary dunes on the ocean side to the back-barrier marshes. The Barrier Ridge and Flat may replace back-barrier marshes as the predominant shoreline environment along narrow sections of the barrier strand, especially in places where overwash is blocked by higher elevations. Characteristic soil groups associated with geomorphic elements of this system are listed in Table 16.

On the Outer Banks, the Barrier Ridge and Flat is the most intensively developed of the four systems, although many areas are not suitable for development. Dune fields are often stabilized by a very sparse cover of grasses and brush or are completely nonvegetated. In these areas, shifting sands present a

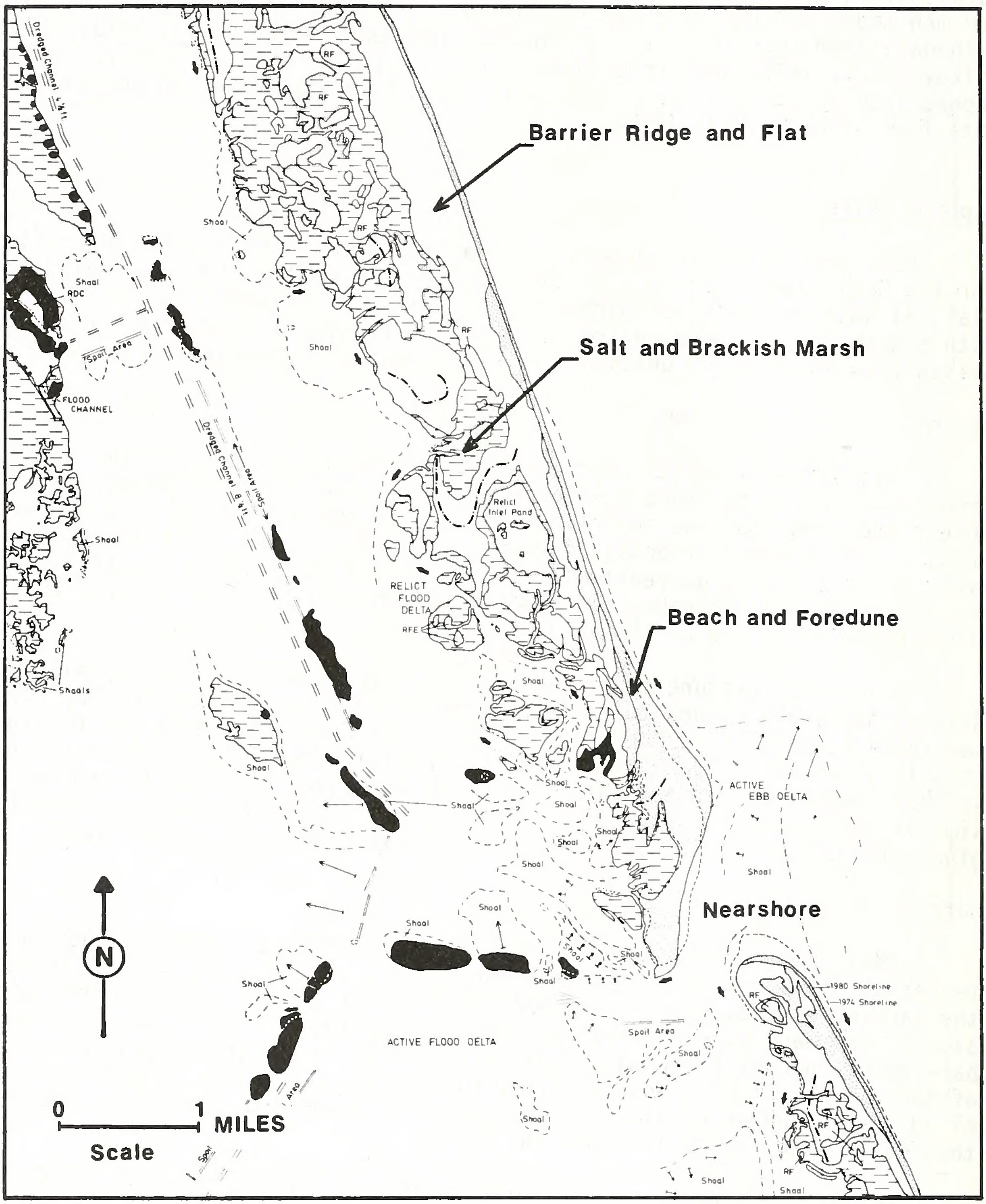
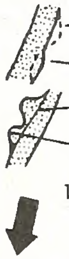
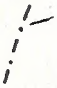
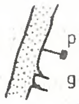
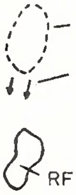
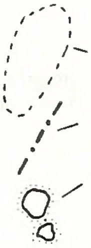
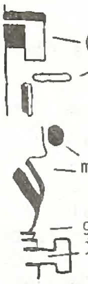
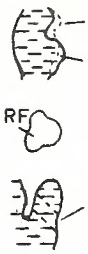
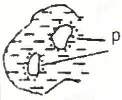
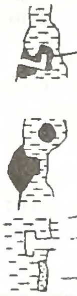
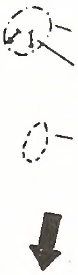
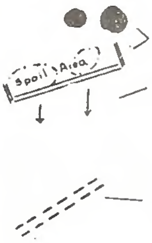


Figure 23. Environmental Systems Mapped for the Outer Banks Region, Active Processes Map Series.

Table 15. Outer Banks Active Processes Mapping Units.

ACTIVE PROCESS UNITS	RELICT FEATURES	MAN-MADE FEATURES
▒ BEACH AND FOREDUNE SYSTEM		
 shoreline erosion shoreline accretion vegetation line storm surge penetration line longshore current direction	 beach and inlet ridges	 piers groins
□ BARRIER RIDGE AND FLAT SYSTEM		
 sand dunes migration directions (RF) recently formed impoundments and ponds	 inactive dunes beach and inlet ridges ponds and impoundments	 (RDC) recently dredged canal made-land groins jetties
▤ SALT AND BRACKISH MARSH SYSTEM		
 shoreline erosion shoreline accretion (RF) recently formed impoundments flood channel	 ponds and impoundments * flood deltas * labled without map symbols	 (RDC) recently dredged canal made-land groins jetties rip rap
□ NEARSHORE SYSTEM - (Sounds and Inlets)		
 shoals migration direction islands eroded below mean sea level longshore current direction		 spoil areas migration direction dredged channels

Note: Former inlet positions and dates for opening and closing are separately labeled.

Table 16. Soil Types and Associations that Correspond to the Geomorphic Elements of the Barrier Ridge and Flat System (for detailed soil information refer to Physical Properties).

Geomorphic Element	Soil Group (from Table 6)	Soil Numbers	
		Outer Banks	Roanoke Island
Dunes and relict ridges	Group I, well-drained to excessively drained mineral soils	14, 15, 21, 22, 23, 24 28	-
Relict dunes, elevated terraces, and sloping flanks of higher ground		-	15, 28, 30
Sand flats	Group II, moderately well-drained mineral soils	7, 8, 9	-
Slightly elevated flats		-	33
Interdune marshes and swales	Group III, poorly drained mineral soils	12, 13	
Level to slightly depressional areas adjacent to brackish marshes, flood plains of streams and Carolina Bays			2, 32, 34
Flood plains of streams and areas adjacent to brackish marshes	Group IV, very poorly drained mineral soils	-	35, 36
Interdune marshes	Group VI, very poorly drained shallow organic soils	20, 26	
Slightly elevated flats adjacent to brackish marshes		-	37, 38

threat to permanent structures, and even well-established vegetation can be disrupted enough by development to initiate sand movement. Although sand flats appear quite stable, they may be poorly suited for development. Sand flats are generally formed by oceanic overwash and are susceptible to flooding or inlet formation. The most stable sand flats are those protected by a high, continuous primary dune ridge. Marshes and swales between dunes are poorly suited for development because of the seasonally high water table and shallow organic soils. Relict ridges are among the stable areas on the barrier strand and are better suited for development.

On Roanoke Island, development is concentrated on relict dunes, elevated flats, and terraces where soils are moderately-to-excessively drained. In these areas, land use is not limited by sand movement, as a dense cover of vegetation effectively binds the soils. Low-lying areas adjacent to brackish marshes, flood plains of minor streams, and depressional areas are characterized by a seasonally high water table and periodic flooding. These areas are filled and drained prior to development and, as a result, are sparsely developed.

Salt and Brackish Marsh System

This system consists of low-lying land areas (0-3 feet above sea level) confined to sound margins of the Outer Banks and Roanoke Island and interior portions along narrow stretches of the barrier strand. Salt Marshes occur in the vicinity of Oregon, Hatteras, and Ocracoke Inlets, and are flooded daily by high tides. In other areas, Brackish Marshes predominate and are flooded less frequently by above normal lunar and wind tides (see Table 17 for corresponding SCS soil numbers). The most extensive marshes occur on the southern end of Roanoke Island and on Bodie Island near Collington and Kitty Hawk.

Table 17. Soil Types that Correspond to Salt and Brackish Marshes (for detailed soils information refer to Physical Properties).

Marsh Type	Soil Numbers
Salt Marshes	
regularly flooded (daily)	6
irregularly flooded (monthly)	18, 19
Brackish Marshes	
irregularly flooded (monthly)	11, 20

Man's activities in this system are dominated by dredging for drainage networks, boat canals, marinas, and residential developments. Sand and gravel dredged from the marshes are generally used as landfill adjacent to the canals. Dredge and fill operations have altered a considerable portion of the marshes, particularly near Collington, Whalebone, and Hatteras Island.

Nearshore System

This system covers the inlets and shallow margins of the sounds adjacent to the Outer Banks and Roanoke Island and consists of shallow sand flats, shoals, and tidal channels. Shoals and sand flats are prevalent behind narrow portions of the barrier strand and are particularly extensive in areas were oceanic overwash has breached the barrier, or where marshes are poorly developed. Large shoals also occur adjacent to erosional shorelines and in the vicinity of flood deltas. Tidal channels are formed on deltas by tidal currents flowing through the inlets.

Dredged channels, subaqueous spoil areas, and man-made islands built from dredge spoil are common features of the Nearshore System.

SUMMARY AND CONCLUSIONS

The Environmental Geologic Atlas of the North Carolina Coastal Zone: Dare, Hyde, Tyrrell, and Washington Counties, is designed to meet immediate agency needs for information and environmental data on the region. Historical, geologic, and geomorphic, as well as other background material, data sources, mapping procedures, explanations of mapping classification systems and mapping units, and information on how to use the maps are included within the text.

Five map titles have been compiled:

1) Physical Properties

2) Mineral and Energy Resources

3) Land Use and Land Cover

4) Drainage and Bathymetry

5) Active Processes

All maps were prepared as transparent overlays. The Mineral and Energy Resources Map was compiled at a scale of 1:126,720 (1 inch=2 miles) using a composite of the N. C. Department of Transportation highway maps as a base. The other four map titles were compiled as map series at a larger scale (1:24,000 or 1 inch=2,000 feet), using 62 of the U. S. Geological Survey 7 1/2 minute topographic quadrangles as base maps. One topographic base map (I-3, Engelhard East) and the four map series overlays that accompany it have been reduced to page size and included in Appendix A for exemplary purposes (Plates I-IV, page A-1-A-4). Keys to the four map series are also included in Appendix A (pages A-5-A-10). Data for the exploratory oil wells are found in Appendix B.

These maps are designed as a current inventory of the physical properties (soils and sediments); land uses (1980-1981); land cover, including wetlands and forest lands (1980-1981); changes in the artificial drainage systems, as well as artificial impoundments and naturally occurring water bodies; bathymetry of sounds; and also as an inventory of both natural and man-induced processes that shape the environmental character of the region.

The atlas text is intended to be utilized as a guide to these maps, which are separate from the body of the text because of their large scale. Individual sets of the four map series have been prepared for each of the four counties. Base maps and county-set copies of overlays and the keys for all four map series, as well as the Mineral and Energy Resource Map, are on file with the N. C. Department of Natural Resources and Community Development and with the Institute for Coastal and Marine Resources at East Carolina University. All maps are available for purchase by the general public for a nominal copying fee.

Several data gaps became apparent during the preparation of this atlas, and the conclusion can be made that additional studies are needed. Detailed SCS soil maps and interpretations are available for Washington and Tyrrell counties but not for Hyde and Dare counties, although some areas have been mapped by private industry. Such surveys do not necessarily integrate easily with the government-prepared material. Detailed information on subaqueous sediments is generally lacking.

Detailed maps and studies of the wetlands and forest lands of the region are few. Tyrrell County is the only part of the study area for which a detailed natural areas inventory exists. Even though the maps for this inventory (McDonald and Ash 1981) were carefully prepared, some did not compare well with recent (1980-1981) aerial photography. This was because the base maps (USGS orthophotoquads) used in the inventory were old (1974) and predated many of the land use and land cover changes brought about by the corporate farm industry since 1974. Additional surveys of natural areas for the other counties would be helpful.

Updating of drainage pattern alterations was done from the 1980-1981 photography. The most recent photorevisions or published maps are dated 1970 to 1979 (USGS 7 1/2 minute topographic quadrangles). Extensive changes in the artificial drainage system have taken place since 1974.

Some of the work done on the Active Processes map series was based on studies by Fisher (1962, 1967). Most interpretations were made from 1980-1981 photography; however, shoreline erosion changes were mapped from 1981 color infrared photography (enlarged from 1:40,000 scale).

A need exists for additional detailed studies on the environmental effects of the continuing large-scale clearing and ditching operations on the peninsula. Windrow burning often violates ambient air quality standards. Burns of the size of the 1980 Pasquotank fire are no longer allowed. A 1981 North Carolina law requires that N. C. Division of Forest Resources permits be obtained and that burn procedures be strictly followed (Wilmington District, 1982). Data that now exist on the hydrologic and water quality impact of such activities are limited to only a few sites. However, drainage of surface waters into primary nursery areas from canals and ditches can create unstable salinity conditions, reduce suitable habitat for food organisms, and thus lower relative productivity of important estuarine organisms (Jones and Sholar 1981). The effects of regionally heavy applications of herbicides, pesticides, fungicides, and fertilizers on water quality are not fully understood. The concern of many government officials and environmentalists that the quality of runoff waters will deteriorate and contaminate wildlife areas, waterfowl feeding sites, and estuarine nursery grounds of various fishes, shrimp, crab, and other organisms can not be alleviated until the nature of these changes has been more thoroughly documented.

Proper planning and management should consider both the consequences of man's alteration of the environment and the reduction of damage caused by natural coastal processes and catastrophes such as hurricanes. Regional planning should consider only further developments or alterations of the coastal zone, both on the mainland and barrier islands, that are compatible with the natural systems.

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APPENDICES

Appendix A. Examples of Map Series, Overlays and Keys

Engelhard East Quadrangle A-1

Active Processes Map Overlay for Engelhard East (I-3), Hyde County (reduced from 1:24,000) A-2

Physical Properties Map Overlay for Engelhard East (I-3), Hyde County (reduced from 1:24,000) A-3

Land Use and Land Cover Map Overlay for Engelhard East (I-3), Hyde County (reduced from 1:24,000) A-4

Drainage and Bathymetry Map Overlay for Engelhard East (I-3), Hyde County (reduced from 1:24,000) A-5

Key to Detailed Physical Properties Maps (Peninsula) A-6

Key to Detailed Physical Properties Maps (Outer Banks and Roanoke Island) A-6

Physical Properties Map Series: Key to General Physical Properties Maps (Peninsula) A-7

Physical Properties Map Series: Key to First Colony Farms Soils (Peninsula) A-7

Key to Land Use and Land Cover Map Series for Outer Banks and Roanoke Island A-8

Key to Land Use and Land Cover Map Series for Albemarle-Pamlico Peninsula A-9

Key to Drainage and Bathymetry Map Series A-10

Outer Banks Active Processes Map Series A-11

Appendix B. Data on Exploratory Oil Wells*: Dare, Hyde, Tyrrell, and Washington Counties

Explanation of Terminology B-1

Dare County B-2

Hyde County B-5

Tyrrell County B-7

Washington County B-8

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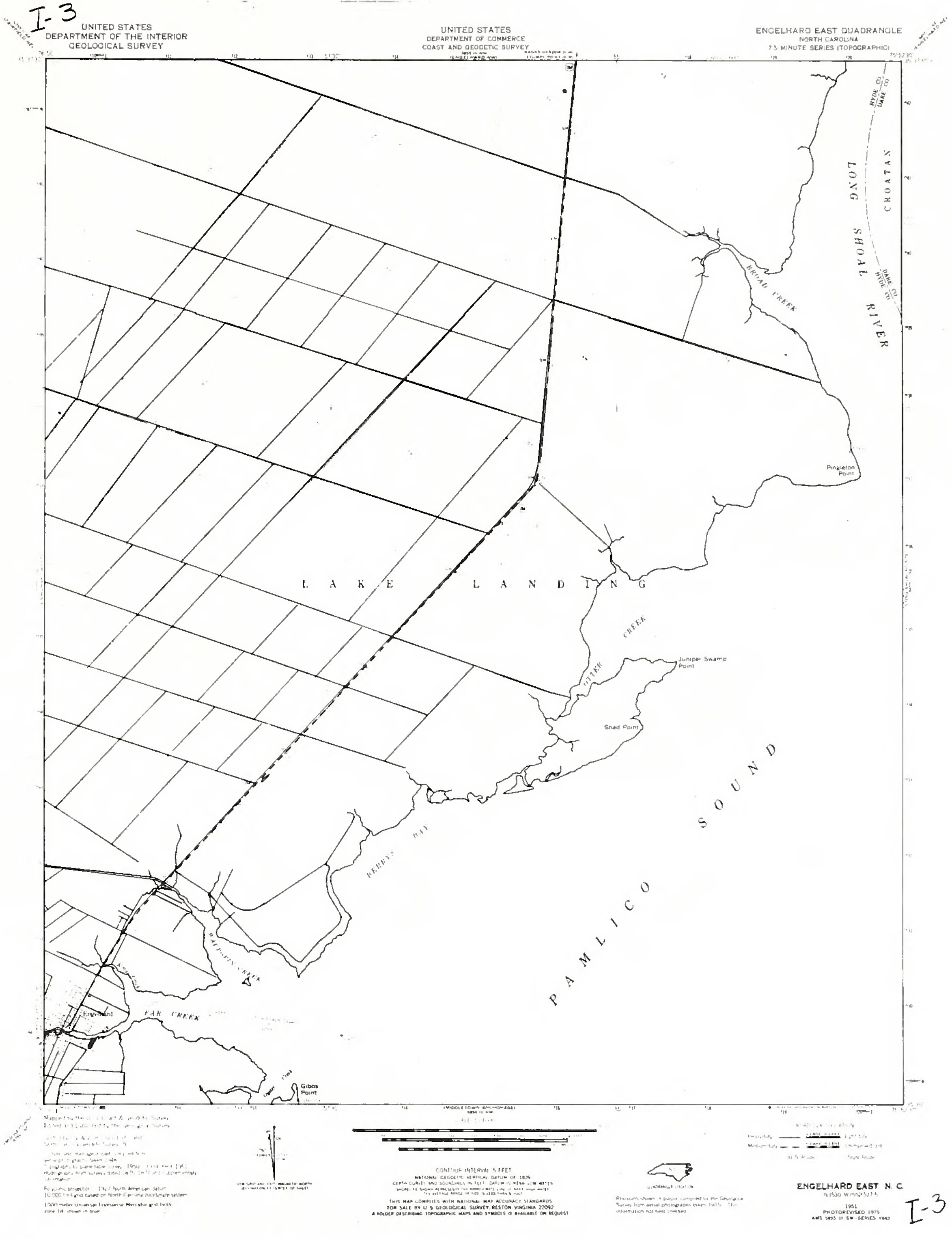
*From Coffey, J.C., 1977, Exploratory oil wells of North Carolina 1925-1976: Geology Min. Resources Sect., N.C. Dept. Natural Econ. Resources, Earth Resources Div., Inf. Circ. 22, 52 p. For copies of this and listing of other N.C. geological publications, contact: Geological Survey Section, Dept. Natural Resources and Community Development, P.O. Box 27687, Raleigh, N.C. 27611.

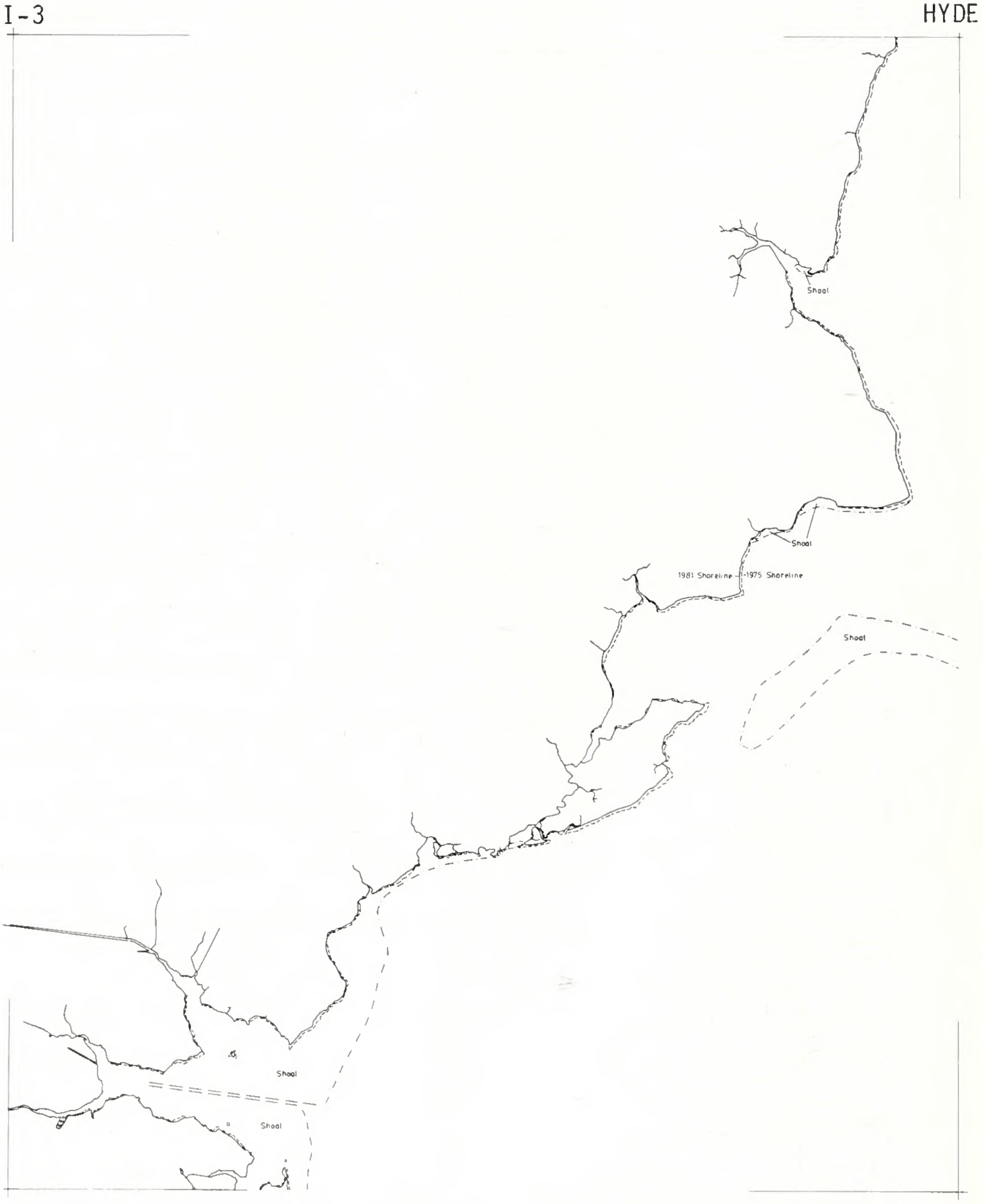
I-3



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
UNITED STATES
DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
ENGELHARD EAST QUADRANGLE
NORTH CAROLINA
7.5 MINUTE SERIES (TOPOGRAPHIC)
75°52'30"
HYDE CO
DARE CO
CROATAN
LONG SHOAL RIVER
BROAD CREEK
Pingleton Point
LAKE LANDING
CREEK
Juniper Swamp Point
Shad Point
BERRYS BAY
PAMLICO SOUND
Engelhard
FAR CREEK
Gibbs Point
CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U S GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
U.S. Route
State Route
ENGELHARD EAST, N. C.
1951
PHOTOREVISED 1975
AMS 5855 III SW—SERIES V842

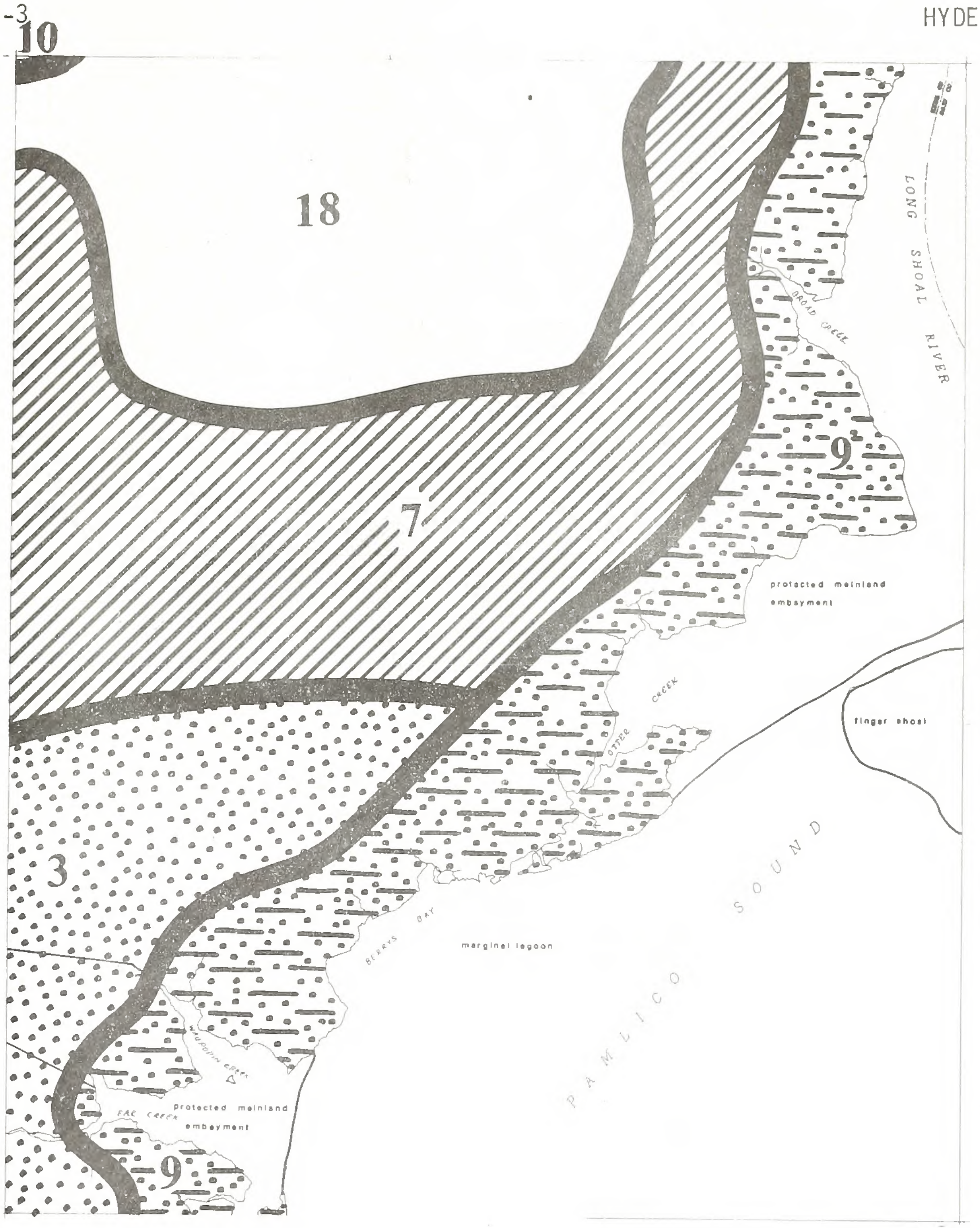
I-3

Engelhard East Quadrangle

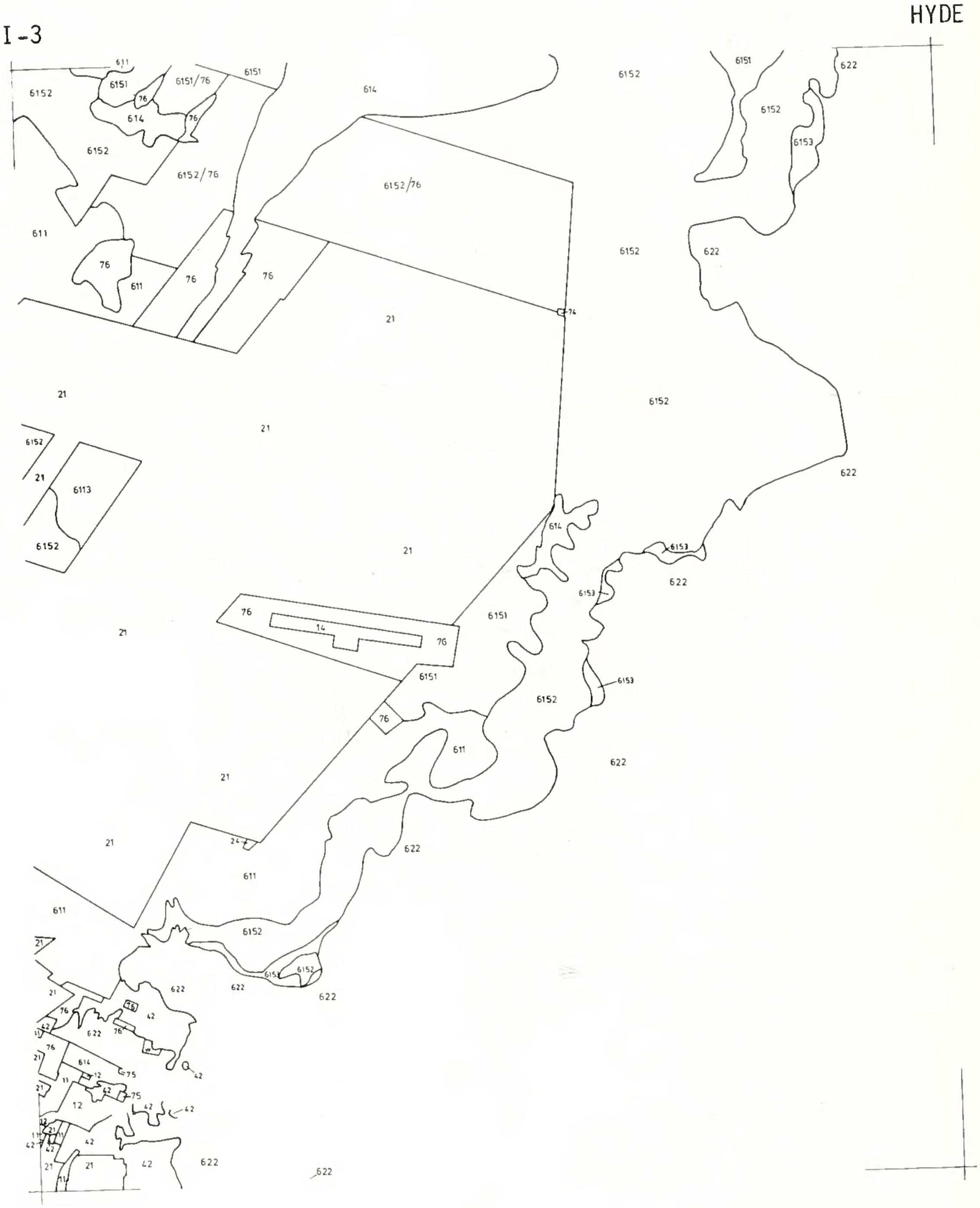


Active Processes Map Overlay for Engelhard East (I-3),
Hyde County (reduced from 1:24,000)

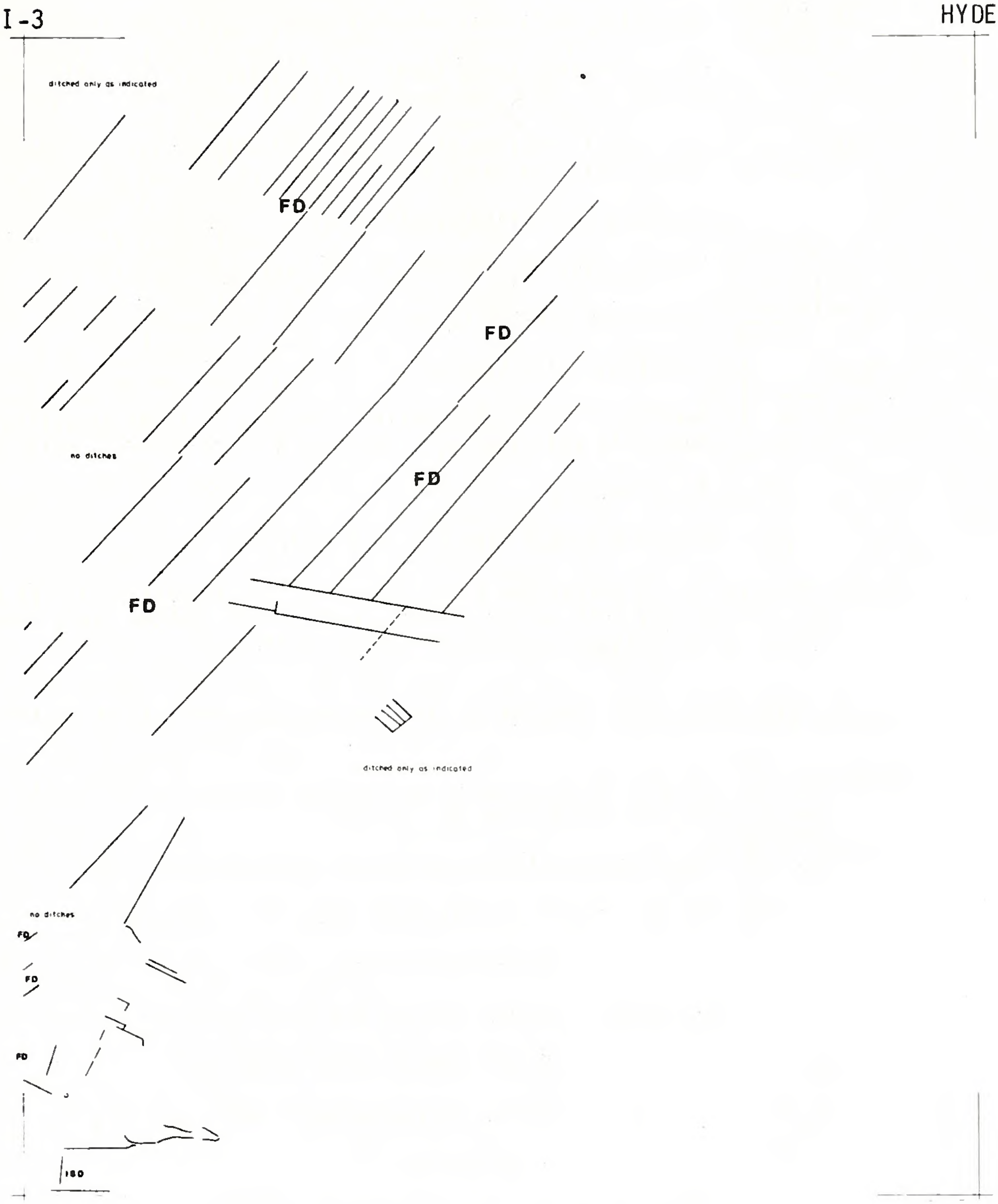
I-3 HYDE



Physical Properties Map Overlay for Engelhard East (I-3), Hyde County (reduced from 1:24,000)



Land Use and Land Cover Map Overlay for Engelhard East (I-3), Hyde County (reduced from 1:24,000)



Drainage and Bathymetry Map Overlay for Engelhard East (I-3), Hyde County (reduced from 1:24,000)

KEY TO DETAILED PHYSICAL PROPERTIES MAPS (PENINSULA)

GROUP		
I	○	Well-drained loamy sands (18, 28, 84, 98), sandy loams (53), and somewhat excessively drained sands (86)
II	■	Moderately well-drained sandy loams (3, 35) and sands (82)
III	░	Poorly drained sandy loams (12, 13, 75, 90, 88), silty loams (9, 54, 56, 94), and loamy sands (41)
IV	▤	Very poorly drained silty loams (43, 51, 95), sandy loams (63), loams (21), and loamy sands (6)
		Very poorly drained organic soils
VI	▨	shallow (15, 24, 57, 60, 78, 80, 92), ≥13" but <51"
VIII	☰	deep, with mineral veneer ≤10" (39)
VII	☐	deep (38, 71), >51"
IX	⊠	Artificial land - properties variable; includes landfills, subaerial and subaqueous spoil piles, and other man-made lands (58)
	⚒	Pit or Quarry
	○	Sewage disposal site (treated effluent)

Note: Numbers listed correspond to those in the classification of soil types, Tyrrell County Soil Survey, Interim Report 1981 (United State Department of Agriculture, Soil Conservation Service).

KEY TO DETAILED PHYSICAL PROPERTIES MAPS (OUTER BANKS AND ROANOKE ISLAND)

GROUP		
I	○	Excessively drained to well-drained mineral soils (1, 3, 14, 15, 21, 22, 23, 24, 25, 27, 28, 30)
II	■	Moderately well-drained mineral soils (7, 8, 9, 33)
III	░	Poorly drained mineral soils (12, 13, 2, 32, 34)
IV	▤	Very poorly drained mineral soils (4, 5, 6, 16, 19, 35, 36)
V	☰	Very poorly drained mineral soils with organic 'veneer' (18, 31)
VII	☐	Very poorly drained deep organic soils (11)
VI	▨	Very poorly drained shallow organic soils (20, 26, 37, 38)
IX	10	Artificial land (10, 17)

Note: Numbers listed correspond to those in the Soil Survey of the Outer Banks, North Carolina, 1977, Dare and Hyde Counties, and to the Roanoke Island soils map (1" = 500'), USDA,Soil Conservation Service.

PHYSICAL PROPERTIES MAP SERIES

KEY TO GENERAL PHYSICAL PROPERTIES MAPS (PENINSULA)

GROUP		
I	○	Excessively drained, well-drained and moderately-drained mineral soils (1)
II	⁘	Poorly drained mineral soils (3,4)
IV	▤	Very poorly drained mineral soils (6, 9, 30)
VI	▨	Very poorly drained shallow organic soils (<51") (7)
VII	☐	Very poorly drained deep organic soils (>51") (10, 18)

Note: Numbers listed in the General Soils Key correspond to soil association symbols taken from Soil Associations of the Coastal Area Management Region, 1977, U.S.D.A., Soil Conservation Service.

KEY TO FIRST COLONY FARMS SOILS (PENINSULA)

9	Poorly drained mineral soils
11, 13, 15, 16, 17, 19, 36	Very poorly drained mineral soils
20, 21, 23, 25	Very poorly drained mineral soils with organic 'veneer' (8-10" deep)
88, 90, 91, 92, 99, 905	Very poorly drained shallow organic soils (<51")
94, 96, 97	Very poorly drained deep organic soils (>51")

Note: Numbers listed in the First Colony Farms Soil Key correspond to soil association symbols taken from the First Colony Farms Soil Survey (see text for details) (Steve Barnes, Agronomist).

KEY TO LAND USE AND LAND COVER MAP SERIES FOR OUTER BANKS AND ROANOKE ISLAND

1. Urban or Built-Up Land

    11. Residential
        111. Mobile Home Park
        112. Single-unit Housing in Open Land Area
        113. Single-unit Housing in Grass and/or Shrub Area
        114. Single-unit Housing in Forested Area
        115. Area Transitional to Residential (streets and drives but no houses, etc.)
        116. Single-unit Housing on Man-made Land

    12. Commercial and Services
        120. Multi-unit Dwelling (including motels, hotels, apartments and condominiums with associated restaurants and piers)
        121. Fire Station and Rescue Squad
        122. Police Department
        123. Hospital, Clinic , and/or Medical Office
        124. Emergency Shelter (established by N.C. Dept. Civil Preparedness)
        125. School
        126. Marina and/or Water Access Area
        127. Campground
        128. Church

    13. Industrial

    14. Transportation, Utilities, Communications, and Information
        140. Weather Station (NOAA)
        141. Electric and Gas Utility
        142. Telephone Company Field Office and/or Microwave Tower
        143. Water Supply Tower or Sewage Treatment Facility
        144. Airstrip and/or Helicopter Pad
        145. Ferry Pier

    15. Industrial and Commercial Complexes

    16. Mixed Urban or Built-up Land

    17. Other Urban or Built-Up Land
        171. Cemetery
        172. Golf Course (including driving ranges/miniature golf)
        173. Intensely Used Recreational Area (such as large parking lots for beach access, tennis courts, water slides, or other such facility not closely integrated into another land use category)
        176. National Historic Site/Monument

2. Agricultural Land

    21. Cropland and Pasture

    24. Other Agricultural Land

3. Rangeland

    33. Grass and/or Shrub Brushland

4. Forest Land

    41. Deciduous Forest Land

    42. Evergreen Forest Land

    43. Mixed Forest Land

6. Wetland

    61. Forested Wetland
        611. Swamp Forest
            6113. Pine-Hardwood Swamp Forest
        615. Evergreen Wetland
            6152. Dense Low Pocosin
            6153. Open Low Pocosin
        616. Intradune Complex-Grass and/or Shrub Wetland
    62. Nonforested Wetland
        621. Freshwater Marsh
        622. Salt or Brackish Marsh
        623. Nonvegetated Flat

KEY TO LAND USE AND LAND COVER MAP SERIES
FOR ALBEMARLE-PAMLICO PENINSULA

1. Urban or Built-Up Land

    11. Residential

    12. Commercial and Services

    13. Industrial

    14. Transportation, Utilities, Communications, and Information

    15. Industrial and Commercial Complexes

    16. Mixed Urban or Built-Up Land

    17. Other Urban or Built-Up Land
        171. Cemetery
        172. Golf Course((including driving ranges/miniature golf)
        173. Intensely Used Recreational Area (such as large parking lots for beach access, tennis courts, water slides, or other such facility not closely integrated into another land use category)
        174. Water Control Structure
        175. Undeveloped Land within an Urban Setting
        176. National Historic Site/Monument

2. Agricultural Land

    21. Cropland and Pastureland

    22. Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas

    23. Confined Livestock Feeding Operations

    24. Other Agricultural Land

4. Forest Land

    41. Deciduous Forest Land

    42. Evergreen Forest Land

    43. Mixed Forest Land

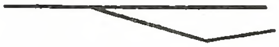
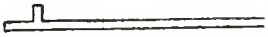
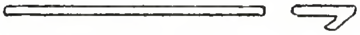
6. Wetlands

    61. Forested Wetland
        611. Swamp Forest
            6112. Atlantic White Cedar Swamp Forest
            6113. Pine-Hardwood Swamp Forest
        614. Disrupted Grass and/or Shrub Wetland
        615. Evergreen Wetland
            6151. High Pocosin
            6152. Dense Low Pocosin
            6153. Open Low Pocosin
            6154. Bay Forest

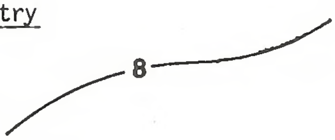
    62. Nonforested Wetland
        621. Freshwater Marsh
        622. Salt or Brackish Marsh
        623. Nonvegetated Flat

KEY TO DRAINAGE† AND BATHYMETRY MAP SERIES

Artificial Canal Systems

1.	FD	indicates field-ditched area, spacing variable from approximately 150 to 350 feet (every fourth or fifth ditch shown in most areas).
2.	ISD	indicates an area with irregularly spaced and/or irregularly oriented ditches, such as those in some managed forestlands or older cultivated areas.
3.	Ditched only as indicated	all canals are shown
4.	No ditches	
5.	No field ditches	
6.		canals
7.		indicates canals on both sides of a road and turn-around
8.		indicates a very wide canal (>40 feet) or an elongate impoundment
9.	- - - - - - - - -	indicates a canal, or portion thereof, that is no longer present (1980-1981 photography) Some of these are mapped on the base maps but have since been filled in; others are portions of newer canals (mapped from the photography) that have not been maintained (in rare instances may also indicate that a road is no longer present at time of mapping).

Bathymetry

 	Subaqueous contour line indicating uniform depth of water

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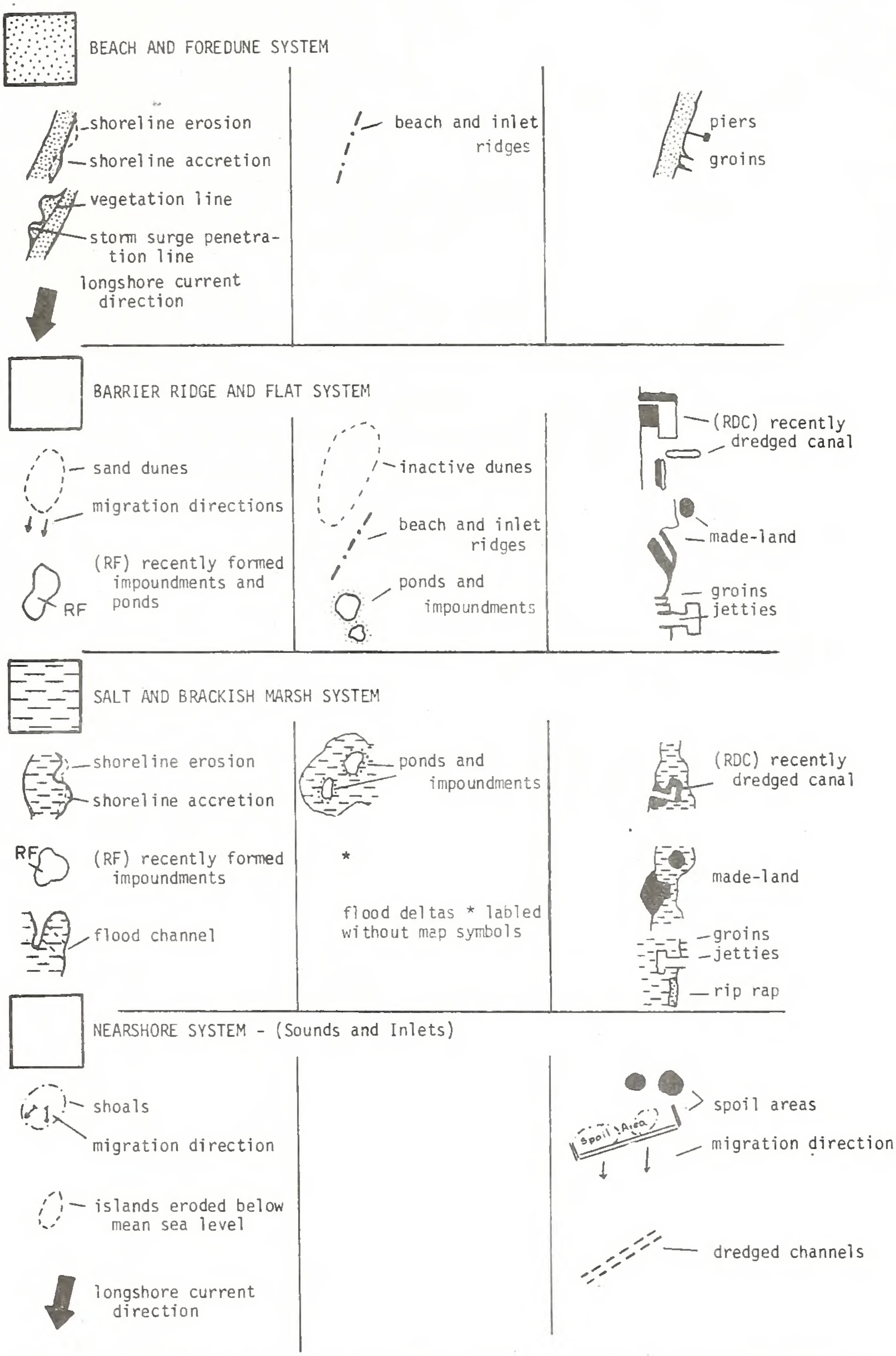
† Canals shown on overlays represent only systems not shown on base maps. Total extent of drainage system must be judged from both overlay and base map.

OUTER BANKS ACTIVE PROCESSES MAP SERIES



ACTIVE PROCESS UNITS	RELICT FEATURES	MAN-MADE FEATURES
BEACH AND FOREDUNE SYSTEM		
shoreline erosion	beach and inlet ridges	piers
shoreline accretion		groins
vegetation line		
storm surge penetration line		
longshore current direction		
BARRIER RIDGE AND FLAT SYSTEM		
sand dunes	inactive dunes	(RDC) recently dredged canal
migration directions	beach and inlet ridges	made-land
(RF) recently formed impoundments and ponds	ponds and impoundments	groins jetties
SALT AND BRACKISH MARSH SYSTEM		
shoreline erosion	ponds and impoundments	(RDC) recently dredged canal
shoreline accretion		
(RF) recently formed impoundments	*	made-land
flood channel	flood deltas * labled without map symbols	groins jetties rip rap
NEARSHORE SYSTEM - (Sounds and Inlets)		
shoals		spoil areas
migration direction		migration direction
islands eroded below mean sea level		dredged channels
longshore current direction		

Note: Former inlet positions and dates for opening and closing are separately labeled.

Explanation of Terminology

API Number: This three-part number comprises the American Petroleum Institute's well designation code. The first, two-digit number is the state code, i.e., 32 stands for North Carolina. The second, three-digit number is the county, e.g., 055 for Dare County. The third number represents the chronological order of well completions within the county, e.g., 1 for the first well drilled within the county.

Chronological Number: This number represents the actual sequence of well completions within the state, e.g., Chron. No. 50 was the fiftieth well drilled within the state.

Basement Depth: This number represents the subsea depth to a pre-Mesozoic "basement" surface. The notation "NR" refers to the fact that basement was "not reached," while "NP" indicates that basement depth was "not picked" in the respective wells.

Total Depth: This number represents the total depth of the well as recorded by the driller's or geophysical log.

Location: The location is given as accurately as possible in terms of degrees, minutes, and seconds of longitude and latitude. An additional location is given in distances from the nearest five minute intervals of longitude and latitude for convenient use on county highway maps.

Driller's Cuttings: "Yes" indicates that sample cuttings are available for examination at the NRCD Division of Land Resources, Geological Survey Section in Raleigh.

Driller's Log: "Yes" means that a geologic record or log kept at the well site during drilling can be reviewed at the office of the Geological Survey Section in Raleigh.

Geophysical Logs: This refers to the types of geophysical logs run on the wells. The original logs can be reviewed at the office of the Geological Survey Section in Raleigh. The abbreviations used are:

I-ES	Induction Electric
GR	Gamma Ray
S	Sonic
SPR	Single Point Resistivity
6L	6-Foot Lateral Resistivity
CAL	Caliper
CCL	Casing Collar Locator
ML	Mud Log
SP	Spontaneous Potential
DIL	Dual Induction Laterlog
D	Density
N	Neutron
CB	Cement Bond
T	Temperature
MCL	Microlog
FT	Formation Tester
16N	16-Inch Normal Resistivity
CD	Continuous Dipmeter
SS	Saraband Synergetic Log

DARE COUNTY

Index
Number*

D-1
API NO.: 32-055-1 WELL NAME: #1 Hatteras Light
CHRON NO.: 3 COMPLETION DATE: 7-15-46
LOCATION: 35° 15' 00"N
75° 31' 45"W
TOTAL DEPTH: 10,044' BASEMENT DEPTH: -9853'
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: I-ES
COMPANY: Standard of New Jersey
1.65 mi. west of 75° 30'W

D-2
API NO.: 32-055-2 WELL NAME: Esso #2 Pamlico Sound
CHRON NO.: 12 COMPLETION DATE: 3-12-47
LOCATION: 35° 42' 12"N
75° 35' 54"W
TOTAL DEPTH: 6410' BASEMENT DEPTH: NR
DRILLERS CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: I-ES
COMPANY: Standard of New Jersey
2.51 mi. north of 35°40'N
0.85 mi. west of 75° 35'W

D-3
API NO.: 32-055-3 WELL NAME: Mobil #1
CHRON NO.: 44 COMPLETION DATE: 7-11-65
LOCATION: 35° 59' 55"N
75° 52' 00"W
TOTAL DEPTH: 5269' BASEMENT DEPTH: -5146'
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: I-ES
COMPANY: Mobil Oil Corp.
0.1 mi. south of 36° 00'N
1.88 mi. west of 75° 50'W

D-4
API NO.: 32-055-4 WELL NAME: Mobil #2
CHRON NO.: 45 COMPLETION DATE: 8-1-65
LOCATION: 35° 26' 20"N
75° 34' 35"W
TOTAL DEPTH: 8386' BASEMENT DEPTH: -8336'
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: I-ES
COMPANY: Mobil Oil Corp.
1.52 mi. north of 35° 25'N
0.39 mi. east of 75° 35'W

D-5
API NO.: 32-055-5 WELL NAME: Marshall Collins #1
CHRON NO.: 49 COMPLETION DATE: 11-5-65
LOCATION: 35° 53' 00"N
75° 40' 15"W
TOTAL DEPTH: 6295' BASEMENT DEPTH: -6266'
DRILLER'S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: I-ES, GR-CAL-S
COMPANY: E. F. Blair & Assoc.
2.28 mi. south of 35° 55'N
0.24 mi. west of 75° 40'W

D-6
API NO.: 32-055-6 WELL NAME: West Va. Pulp
& Paper #1
CHRON NO.: 50 COMPLETION DATE: 12-1-65
LOCATION: 35° 51' 50"N
75° 55' 30"W
TOTAL DEPTH: 5147' BASEMENT DEPTH: -5119'
DRILLER'S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: I-ES, GR-N, D-CAL
COMPANY: E. F. Blair & Assoc.
2.09 mi. north of 35° 50'N
0.47 mi. west of 75° 55'W

D-7
API NO.: 32-055-7 WELL NAME: Etheridge #1
CHRON NO.: 68 COMPLETION DATE: 11-16-69
LOCATION: 35° 55' 26"N
75° 40' 38"W
TOTAL DEPTH: 6049' BASEMENT DEPTH: NR
DRILLER"S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: I-ES
COMPANY: Rapp Oil Corp.
0.5 mi. north of 35° 55'N
0.6 mi. west of 75° 40'W

Index
Number*

D-8 API NO.: 32-055-8 WELL NAME: L. Twiford #1 COMPANY: Rapp Oil Corp.
CHRON NO.: 69 COMPLETION DATE 12-8-69 2.5 mi. north of 35° 40'N
LOCATION: 35° 42' 12" N 1.2 mi. west of 75° 45'W
75° 46' 17"W
TOTAL DEPTH: 5940' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: I-ES, GR-CAL-S, GR-N, CB, T

D-9 API NO.: 32-055-9 WELL NAME: Westvaco #1A COMPANY: Cities Service
CHRON NO.: 101 COMPLETION DATE: 9-23-71 0.46 mi. south of 35° 40'N
LOCATION: 35° 39' 36"N 1.56 mi. west of 75° 45'W
75° 46' 40"W
TOTAL DEPTH: 6288' BASEMENT DEPTH: -6112'
DRILLER'S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: I-ES, GR-N-CAL, GR-D, DIL,
GR-CAL-S, MCL

D-10 API NO.: 32-055-10 WELL NAME: Westvaco #2A COMPANY: Cities Service
CHRON NO.: 102 COMPLETION DATE: 10-7-71 2.05 mi. north of 35° 50'N
LOCATION: 35° 51' 48"N 1.0 mi. west of 75° 50'W
75° 51' 04"W
TOTAL DEPTH: 5817' BASEMENT DEPTH: -5409'
DRILLER'S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: I-ES, GR-CAL-N, GR-CAL-D, GR-CAL-S, FT

D-11 API NO.: 32-055-11 WELL NAME: Westvaco #1 COMPANY: Gentles
CHRON NO.: 111 COMPLETION DATE: 8-25-73 0.28 mi. north of 35° 45'N
LOCATION: 35° 45' 15"N 1.29 mi. west of 75° 45'W
75° 46' 22"W
TOTAL DEPTH: 5320' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: No/Yes GEOPHYSICAL LOGS: GR

D-12 API NO.: 32-055-12 WELL NAME: Westvaco #2 COMPANY: Gentles
CHRON NO.: 112 COMPLETION DATE: 8-25-73 0.28 mi. north of 35° 45'N
LOCATION: 35° 45' 15"N 1.31 mi. west of 75° 45' W
75° 46' 24"W
TOTAL DEPTH: 6079' BASEMENT DEPTH: -6057'
DRILLER'S CUTTINGS/LOG: No/No GEOPHYSICAL LOGS: I-ES, GR-CAL-S, GR-CAL-D

D-13 API NO.: 32-055-13 WELL NAME: Westvaco #3 COMPANY: Gentles
CHRON NO.: 113 COMPLETION DATE: 10-7-73 1.6 mi. north of 35° 40'N
LOCATION: 35° 41' 24"N 1.71 mi. west of 75° 45'W
75° 46' 49"W
TOTAL DEPTH: 5880' BASEMENT DEPTH: -5809'
DRILLER'S CUTTINGS/LOG: No/No GEOPHYSICAL LOGS: I-ES, GR-CAL-S

D-14 API NO.: 32-055-14 WELL NAME: First Colony Farms #1 COMPANY: Cities Service
CHRON NO.: 118 COMPLETION DATE: 4-4-74 1.92 mi. south of 35° 50'N
LOCATION: 35° 48' 19"N 2.07 mi. east of 75° 50'W
75° 47' 48"W
TOTAL DEPTH: 5582' BASEMENT DEPTH: -5530'
DRILLER'S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: I-ES, GR-CAL-S

Index
Number*

D-15
API NO.: 32-055-15 WELL NAME: First Colony Farms #A-2
CHRON NO.: 119 COMPLETION DATE: 4-27-74
LOCATION: 35° 56' 38"N
75° 52' 20"N
TOTAL DEPTH: 5260' BASEMENT DEPTH: -5209'
DRILLER'S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: I-ES, GR-CAL-D, GR-CAL-S, GR-N, FT

COMPANY: Cities Service
1.86 mi. north of 35° 55'W
2.19 mi. west of 75° 50'W

*Numbers refer to wells as mapped on the Mineral and Energy Resources Map (1:126,720).

HYDE COUNTY

Index
Number

H-1 API NO.: 32-095-1 WELL NAME: Rhem #1 COMPANY: Davidson Oil
CHRON NO.: 19 COMPLETION DATE: 11-6-51 0.95 mi. north of 35° 35'N
LOCATION: 35° 35' 50"N 0.7 mi. west of 76° 30'W
76° 30' 45"W
TOTAL DEPTH: 3123' BASEMENT DEPTH: NP
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: None

H-2 API NO.: 32-095-2 WELL NAME: F. F. Spencer, Jr. #1 COMPANY: Coastal Plains Oil
CHRON NO.: 22 COMPLETION DATE: 3-28-59 2.7 mi. north of 35° 30'N
LOCATION: 35° 32' 22"N 0.8 mi. west of 76° 10'W
76° 10' 51"W
TOTAL DEPTH: 1635' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: None

H-3 API NO.: 32-095-3 WELL NAME: D. Q. Holton #1 COMPANY: Coastal Plains Oil
CHRON NO.: 23 COMPLETION DATE: 4-3-59 2.57 mi. south of 35° 35'N
LOCATION: 35° 32' 45"N 1.41 mi. east of 76° 15'W
76° 13' 30"W
TOTAL DEPTH: 2005' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: None

H-4 API NO.: 32-095-4 WELL NAME: J. L. Simmons, Jr. #1 COMPANY: Coastal Plains Oil
CHRON NO.: 24 COMPLETION DATE: 4-10-59 2.28 mi. north of 35° 20'N
LOCATION: 35° 22' 00"N 1.88 mi. east of 76° 20'W
76° 18' 00"W
TOTAL DEPTH: 1685' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: None

H-5 API NO.: 32-095-5 WELL NAME: J. L. Simmons, Jr. #2 COMPANY: Coastal Plains Oil
CHRON NO.: 25 COMPLETION DATE: 4-18-59 0.95 mi. south of 35° 30'W
LOCATION: 35° 29' 10"N 0.78 mi. east of 76° 20'W
76° 19' 10"W
TOTAL DEPTH: 2005' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: None

H-6 API NO.: 32-095-6 WELL NAME: W. Williams #1 COMPANY: Coastal Plains Oil
CHRON NO.: 26 COMPLETION DATE: 4-22-59 2.85 mi. north of 35° 25'N
LOCATION: 35° 27' 30"N 2.35 mi. east of 76° 20'W
76° 17' 30"W
TOTAL DEPTH: 2005' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: None

H-7 API NO.: 32-095-7 WELL NAME: M. M. Swindell #1 COMPANY: Coastal Plains Oil
CHRON NO.: 27 COMPLETION DATE: 4-28-59 2.8 mi. north of 35° 25'N
LOCATION: 35° 27' 27"N 0.1 mi. west of 76° 15'W
76° 15' 06"W
TOTAL DEPTH: 2005' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: None

Index
Number

H-8 API NO.: 32-095-8 WELL NAME: J. M. Ballance #1 COMPANY: Coastal Plains Oil
0.8 mi. south of 35° 35'N
1.8 mi. east of 76° 10'W
CHRON NO.: 28 COMPLETION DATE: 5-3-59
LOCATION: 35° 34' 18"N
76° 08' 05"W
TOTAL DEPTH: 2005' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: None

H-9 API NO.: 32-095-9 WELL NAME: Mobil #3 Pamlico Sound COMPANY: Mobil Oil Corp.
2.0 mi. south of 35° 20'N
0.24 mi. east of 75° 50'W
CHRON NO.: 46 COMPLETION DATE: 8-23-65
LOCATION: 35° 18' 25"N
75° 49' 45"W
TOTAL DEPTH: 7314' BASEMENT DEPTH: -7236'
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: I-ES

H-10 API NO.: 32-095-10 WELL NAME: O. Ballance #1 COMPANY: E. F. Blair & Assoc.
2.76 mi. north of 35° 25'N
1.72 mi. west of 76° 00'W
CHRON NO.: 51 COMPLETION DATE: 12-22-65
LOCATION: 35° 27' 25"N
76° 01' 50"W
TOTAL DEPTH: 5570' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: GR-N

TYRRELL COUNTY

Index
Number

T-1
API NO.: 32-177-1 WELL NAME: Westvaco #2
CHRON NO.: 103 COMPLETION DATE: 11-14-71
LOCATION: 35° 53' 33"N
76° 09' 35"W
TOTAL DEPTH: 4198' BASEMENT DEPTH: -3882'
DRILLER'S CUTTINGS/LOG: Yes/No GEOPHYSICAL LOGS: DIL, GR-CAL-N, GR-CAL-D

COMPANY: Exchange Oil & Gas
1.65 mi. south of 35° 55'N
0.4 mi. east of 76° 10'W

T-2
API NO.: 32-177-2 WELL NAME: Westvaco #1
CHRON NO.: 104 COMPLETION DATE: 11-29-71
LOCATION: 35° 47' 56"N
76° 12' 20"W
TOTAL DEPTH: 4242' BASEMENT DEPTH: -4064'
DRILLER'S CUTTINGS/LOG: Yes/N GEOPHYSICAL LOGS: DIL

COMPANY: Exchange Oil & Gas
2.35 mi. south of 35° 50'N
2.2 mi. west of 76° 10'W

T-3
API NO.: 32-177-3 WELL NAME: Westvaco #3
CHRON NO.: 105 COMPLETION DATE: 12-13-71
LOCATION: 35° 43' 02"N
76° 06' 17"W
TOTAL DEPTH: 4855' BASEMENT DEPTH: -4734'
DRILLER'S CUTTINGS/LOG: No/No GEOPHYSICAL LOGS: DIL

COMPANY: Exchange Oil & Gas
2.25 mi. south of 35° 45'N
1.2 mi. west of 76° 05'W

T-4
API NO.: 32-177-4 WELL NAME: Whitehurst #1
CHRON NO.: 106 COMPLETION DATE: 12-15-71
LOCATION: 35° 48' 15"N
76° 20' 43"W
TOTAL DEPTH: 3564' BASEMENT DEPTH: -3487'
DRILLER'S CUTTINGS/LOG: No/No GEOPHYSICAL LOGS: I-ES, GR-SP-SPR

COMPANY: R. H. Dekay
2.0 mi. south of 35° 50'
0.67 mi. west of 76° 20'W

T-5
API NO.: 32-177-5 WELL NAME: White #1
CHRON NO.: 107 COMPLETION DATE: 4-22-72
LOCATION: 35° 44' 47"N
76° 08' 56"W
TOTAL DEPTH: 4315' BASEMENT DEPTH: NP
DRILLER'S CUTTINGS/LOG: No/No GEOPHYSICAL LOGS: DIL, GR-CAL-D, CD

COMPANY: Kit Development Co., Dekay
0.25 mi. south of 35° 45'N
1.0 mi. east of 76° 10'W

WASHINGTON COUNTY

W-1 API NO.: 32-187-1 WELL NAME: Roper #1 COMPANY: Davidson Oil
CHRON NO.: 17 COMPLETION DATE: 9-10-51
LOCATION: 35° 52' 45"N
76° 37' 00"W
2.57 mi. south of 35° 55'N
1.88 mi. west of 76° 35'W
TOTAL DEPTH: 2223' BASEMENT DEPTH: NR
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: None

W-2 API NO.: 32-187-2 WELL NAME: Furbee #1 COMPANY: Davidson Oil
CHRON NO.: 18 COMPLETION DATE: 10-10-51
LOCATION: 35° 43' 30"N
76° 37' 30"W
1.71 mi. south of 35° 45'N
2.35 mi. west of 76° 35'W
TOTAL DEPTH: 2693' BASEMENT DEPTH: -2673'
DRILLER'S CUTTINGS/LOG: Yes/Yes GEOPHYSICAL LOGS: I-ES

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4. Cribbins, P. S. An Analysis of State and Federal Policies Affecting Major Energy Projects in North Carolina's Coastal Zone. CEIP Report #4. September 1981. $10. (NTIS # PB82-202920)

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9. Fussell, J. O., III, and E. J. Wilson. Natural Areas Inventory of Carteret County, North Carolina. CEIP Report #9. June 1983. $10.

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17. Stone, John R., Michael T. Stanley, and Paul T. Tschetter. Coastal Energy Transportation Study: Impacts of Increased Rail Traffic on Communities in Eastern North Carolina. CEIP Report # 17. August 1982. $10. (NTIS # PB83-203075)

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